COMPUTER AID IN THE MANAGEMENT OF JUVENILE DIABETES MELLITUS

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ABSTRACT

There are 250,000 insulin dependent diabetics in England and Wales of which 30,000 are children. The aim of this research thesis is to investigate the problem of diabetic control in juveniles and the role that a computer might play in the management of an individual diabetic child. Currently available management aids are critically reviewed. On this basis it is established that there is a need for a system to aid the management of diabetes in the home.

The related areas of expert systems and interface design are explored as a basis of the system design. Knowledge acquisition has been carried out by direct observation of the diabetic clinician. A recursive algorithm for diabetic management, based on the times when particular insulins are most effective and the "most likely causes" of hypoglycaemia or hyperglycaemia, has been formulated. In addition the algorithm has been presented in the form of an "advice chart" which could easily be produced for the individual diabetic child on a sheet of A4 paper. A diabetic management system aimed at advising the diabetic in his/her home has been produced. It is a flexible system with a clinician's option to allow the amending of advice text and management guidelines. The system is tailored to the individual diabetic and provides further facilities including the capturing of data and offering a source of general information.

The ethical and legal issues related to medical advisor systems are considered in detail, particularly where they relate to system evaluation. A formal evaluation of data entry involving a total of forty users has been completed. Both the usability of data entry facilities and acceptability of system advice were examined. The reaction of the users was mixed. Those who found the system most acceptable were diabetic teenagers. Those who were most in need of decision support were the families of the newly diagnosed diabetic. All users indicated that the system facilities to record blood test results will only be utilised if there is a direct benefit to blood sugar control. The evaluation suggests that, although ethical and legal considerations remain unsolved, this system would provide some benefit to sufferers of Juvenile Diabetes Mellitus on both diabetic education and blood glucose control.

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CHAPTER 1

Introduction

1.1. Computers in Medicine

Computers are widely used in all aspects of our daily lives, from banking to education and health care.

The National Health Service uses computers for both routine hospital administration and specialist patient care. Computers have been applied to certain medical areas for many years, for example, medical education, patient records and patient monitoring.

Recent advances in the fields of knowledge engineering and expert systems have led to medical computer systems which utilise the latest technological expertise. The application of these techniques to clinical decision making is discussed in detail in chapter 5. Such technology has been used to enhance rather than replace the clinicians' expertise in disease diagnosis and subsequent treatment, a notable example being that of computer-aided diagnosis of acute abdominal pain (De Dombal et al, 1972, De Dombal et al, 1974).

Clinical decision support has traditionally been based in hospitals but there is a gradual move towards computers being used in general practice and specialist clinics, for example, St. Thomas's Hospital, London is developing an expert system to aid general practitioners in the care of adult diabetics (Brown, 1985).

Expanding this concept, with the availability of inexpensive micro computers, it is feasible to consider offering limited computer medical aid in the patient's home.

Diabetes is a condition where it may be an advantage to use a computer system to enhance traditional methods of management. Diabetes presents a continual dynamic control problem which is at present managed at home by the individual diabetic supported by visits to the clinician at only approximately three monthly intervals. It is thus appropriate to investigate the possibility of a home based microcomputer to aid in decision making inherent in the problem of diabetic management.

1.2. Diabetes

It is estimated by the British Diabetic Association that there are 250,000 insulin dependent diabetics in England and Wales. Approximately 30,000 are under the age of sixteen. Diabetes mellitus is diagnosed at a rate of 30,000 new patients per year, five percent of new cases being children.

Diabetes occurs when the pancreas produces insufficient insulin to control the glucose level in the blood, the exact clinical condition is described in chapter 2. If virtually no insulin is produced then treatment of insulin by injection is essential. This type of diabetes develops rather suddenly with the patient losing weight, feeling excessively tired and passing large amounts of urine, leading to unnatural thirst (Kinmonth et al, 1982).

Day to day patient management is controlled by the diabetic or in the case of children, their parents. The achievement of a balance between insulin, diet and activity is made difficult by changes in both physiological and psychological status. In particular, managing diabetes is more difficult in children because of the child's growth, changing developmental status and unpredictable activity levels. Despite the immense difficulty of this control task, diabetics have little choice but to aim to achieve a continuous dynamic balance so as to avoid the problems of both hyper and hypoglycaemia (too much and too little glucose in the blood) since it is believed that the degradation of certain physiological functions occur in both states (Gale, 1980).

Parents of diabetic children often have difficulty in adjusting insulin because they do not understand the "rules" of diabetic management. Choosing the correct type and quantity of insulin to change in order to answer a particular diabetic question means solving a scientific problem, the methods of which may be unfamiliar. In addition, the consequences of poor blood sugar control may not be fully appreciated, resulting in persistent poor control until the clinician is visited.

1.3. Diabetic Computer Aid

The aim of this thesis was to identify procedures of diabetic management for the insulin dependent juvenile diabetic and examine the role of a home based microcomputer to aid diabetic management. This involved an initial evaluation of the system in order to assess user acceptability.

Varying types of electronic devices have been designed and developed to aid diabetic management and by investigating both their positive and negative features it was possible to identify the requirements of such a computer system (chapter 4).

The initial approach was to explore the use of expert systems in clinical decision making and their possibilities are considered in detail in chapter 5.

Expert knowledge in the field of diabetic management was gathered from both the clinician and literature. The information was organised and formulated in a style to be utilised efficiently by a microcomputer and it is described in chapter 6.

The interface and dialogue of this system were carefully designed with the novice user at the forefront of consideration. The most recent methods were explored and the requirements of the system specified in chapters 7 and 8.

The home computer market is advancing in technology and is increasingly competitive and therefore the system specification in Chapter 9 is detailed and independent of machine type. However, the implementation on an IBM compatible PC is then described in Chapter 12.

The availability of an inexpensive computer aid based on the methods of diabetic management that are open to inspection and amendment may offer important benefits to the day to day control of diabetes. Chapter 13 considers the ethical and legal issues related to Medical Advisor Systems before describing the methods and results of an initial system evaluation. Chapter 14 discusses the achievements of this work and the conclusions of the initial evaluation.

CHAPTER 2
Diabetes Mellitus

2.1. Introduction

Diabetes is a disorder in which the level of blood glucose is persistently raised above the normal range due to a lack of insulin. It is a common condition and occurs in all parts of the world. Diabetes, particularly juvenile onset, may be treated with a combination of insulin and diet. Although visits to diabetic clinics take place at regular intervals, during the time between visits the child and family must manage the condition alone. Managing the diabetic child presents a particularly difficult control task because of the child's growth, changing developmental status and unpredictable activity level.

The objective of this thesis is to enhance traditional management methods, in particular the management of childhood diabetes. The control problems of diabetic management are discussed in detail in chapter 3. To appreciate fully the goals of management and identify in detail the problems of the control task, it is necessary to describe briefly the physiological condition of diabetes and its diagnosis. A further and more detailed explanation is given in Diabetes and its Management, W.G. Oakley, D.A. Pyke and K. Taylor, 1978.

2.2. The Physiological Description of Diabetes

2.2.1. Definition

Butterworth's Medical Dictionary (Macdonald Critchley, 1978) defines Diabetes Mellitus as

"a disease, of which there are several forms, characterised by a high-fasting blood sugar, an exaggerated rise in the blood sugar after the ingestion of glucose and a failure of the blood sugar to return in a normal time to normal values. In the juvenile form the clinical characteristics are hyperglycaemia, glycosuria, polydipsia, wasting and ketosis, culminating in coma and death. In the senile form, wasting does not occur, obesity is common, ketosis is absent or mild and coma is rare, death occurring by reason of late complications. The late complications in both types are arterial changes, glomerular nephrosis, retinitis and cataract. The pancreas, anterior pituitary gland, adrenal cortex and liver may each be concerned in its aetiology."

The definition indicates that a fundamental aspect of diabetes is the failure to control blood sugar levels. It is thus essential to understand the importance of blood glucose control in a normal individual.

2.2.2. Blood Sugar Control

Blood glucose levels are normally held between the narrow limits of 3.0 mmols/l and 7.0 mmols/l. The maintenance of a normal blood glucose level is essential because some tissues such as the brain rely principally on glucose for their metabolism. A fall in blood levels below the lower normal limit results in a serious disturbance of mental function and may lead to coma. If blood glucose levels rise above the upper normal limit then diuresis and dehydration may result. In contrast, in normal non-diabetic individuals, the normal blood glucose levels are strictly maintained (see Figure 1) even during starvation or over-eating.

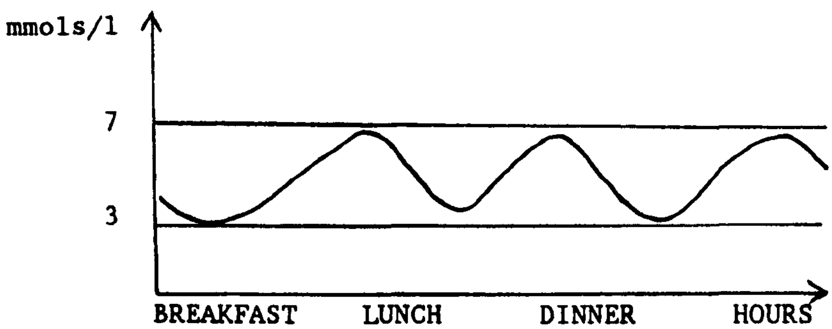


FIGURE 1 Blood Glucose Levels in a Non-Diabetic

The absorption of glucose from the gut and its synthesis in the liver increase the blood glucose level. The uptake of glucose from the blood by body tissues decreases its levels (see Figure 2)

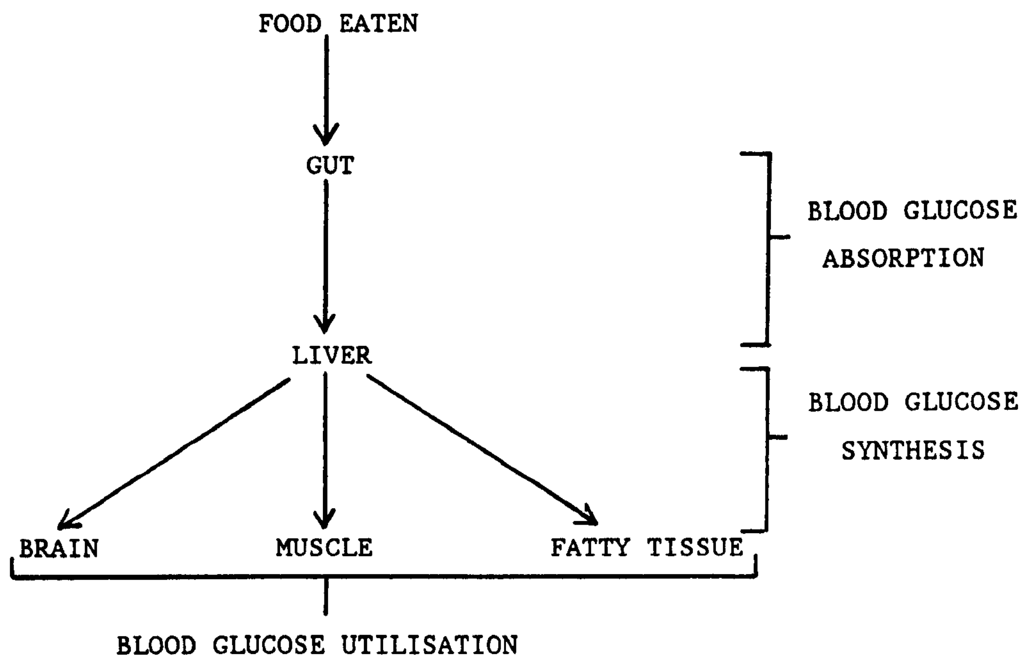


FIGURE 2 Blood Glucose Utilisation

2.2.3. Human Metabolism

Carbohydrate metabolism

Blood glucose rises after eating carbohydrate mainly because starch is broken down to glucose and it is carried to the liver where the excess glucose is stored as glycogen. In times of shortage of carbohydrate, glycogen is broken down to glucose and released into the blood stream.

Protein metabolism

Protein is broken down in the gut to form amino acids. Amino acids may be carried to the liver or used to synthesise protein in muscle or kidney. Certain amino acids can be metabolised to glucose and this process may lead to severe loss of body protein during prolonged starvation.

Gluconeogenesis

Gluconeogenesis produces glucose from non-glucose sources especially protein and also from the glycerol variety of fat. It is an important process for the maintenance of blood sugar when food is not available for long periods of time. Diabetes greatly accelerates gluconeogenesis because the glucose obtained from the gut cannot be utilised due to the lack of insulin. The rise of blood sugar in the untreated diabetic is substantially contributed to by the described protein breakdown.

Fat metabolism

Fat consists of a combination of fatty acids with glycerol and it is stored in the adipose tissue cells subcutaneously in the omentum and around the viscera. When fat is broken down it releases free fatty acid and glycerol, a process which is regulated by hormones such as growth hormone and glucagon. Fat provides a store of oxidisable material which is available during prolonged carbohydrate shortage. Thus fat stores are broken down during starvation and diabetes.

Breakdown of fatty acids and formation of ketones

Normally fatty acids are oxidised in the liver to produce water and carbon dioxide. When there is an excessive breakdown of fatty acids acetoacetate is produced instead, giving rise to high levels of ketone bodies in the blood. Ketone levels rise during starvation when fat is broken down to provide energy but the levels are much higher in uncontrolled or untreated diabetes. Ketones are excreted in the urine and breath.

Insulin

Insulin lowers blood glucose and it also has important effects on the metabolism of protein and fat. The action of insulin is both rapid and delayed.

Rapid effects:

1. Glucose uptake into cells and its further metabolism is increased.
2. Fatty acid release from adipose tissue is depressed.
3. Glycogen formation in liver is increased.
4. Protein synthesis especially in muscle tissue increases.

Insulin lowers the blood glucose by increasing glucose uptake by the tissues and also by increasing the deposition of body fat at the expense of glucose.

Long term effects:

1. Enzyme activity involved in glucose metabolism is increased.
2. Enzyme activity involved in gluconeogenesis is depressed.

Insulin builds up complex molecules such as glycogen and fat from simpler material such as glucose. When insulin is absent the complex molecules readily break down and this is the reason for excessive weight loss in the insulin deficient diabetic.

Tissue responsiveness to insulin

Insulin has a direct effect (within 15 minutes) on some body tissue. Muscle and adipose tissue are sensitive to small concentrations of circulating insulin and respond within minutes of its administration. However, some other tissues, for example, the brain do not appear to respond to insulin. Early effects of insulin are mainly its action on liver, muscle and fatty tissue.

Insulin lack - the metabolic consequences

When the human body is deprived of insulin, the transport of glucose into muscle and adipose tissue is restricted resulting in a rise of blood glucose. Neutral fat is broken down to produce free fatty acids, glycerol is increased and there is a rise in the fatty acid content of the blood. The rise of fatty acids in turn give rise to ketone body levels increasing which pass to the muscles for further oxydisation. Ketone levels increase as the diabetic state worsens and as their capacity for oxydisation is exceeded, ketosis becomes progressively more severe.

Protein breakdown is greatly increased because less amino acids are taken up by tissues. Concurrently, the enzymes responsible for gluconeogenesis are activated by the absence of insulin with a consequent increase in the production of glucose, mainly from the liver and at the expense of protein. Protein and fat synthesis are depressed and when prolonged, leads to an increase in their breakdown.

The above changes can be reversed by insulin but some, such as gluconeogenesis may take many hours.

Continuing on the theme of the physiological description of diabetes it is appropriate to briefly discuss its diagnosis.

2.3. Diagnosis

Diabetes can be divided into two clinical types, the ketosis-prone (insulin dependent) and the non-ketosis-prone patient. However, many cases lie between them. Its diagnosis depends upon:

a. clinical features
b. glycosuria
c. raised blood sugar

Clinical features and glycosuria may not be present for diagnosis but without raised blood sugar, diabetes cannot be diagnosed.

The classic symptoms of extreme thirst, passing excessive urine, tiredness and weight loss are usually manifest in the insulin dependent diabetic. The onset of these symptoms may be gradual but it is often dramatic in onset and there may be associated dehydration. Immediately preceding the onset of symptoms there may be a weight gain due to the metabolic disorder. At the same time there may have been symptoms such as faintness and sweating just before meals.

Nocturnal enuresis may occur in children and this juvenile type of diabetes is more acute than maturity onset diabetes which is often relatively slow in onset. Symptoms may have occurred up to a year before diagnosis but were concealed, ignored or misinterpreted.

The great majority of juvenile onset diabetics have definite symptoms and the excessive urination will be caused by glycosuria. If a young person who is suspected on clinical grounds of being diabetic shows no sugar in the urine, it is unlikely that the diagnosis is correct. A blood sugar test should always be done to confirm the diagnosis of diabetes.

As soon as diagnosis is complete the insulin dependent diabetic must take insulin by injection between 1 and 4 times per day. In addition, the regime of diabetic management involves diet, exercise and monitoring blood and/or urine test results. Visits to the diabetic clinic will occur at regular intervals but between clinic visits, the diabetic must manage their condition every day for the rest of their life.

2.4. Summary

This chapter has briefly described the physiological condition of diabetes and has attempted to identify the juvenile onset, insulin dependent diabetic as the group of diabetics that present a dynamic control task and therefore may require help in managing their condition.

To identify the particular control problems of this type of diabetes, the regime of management and its different aspects, including the role of carbohydrate, exercise and insulin, must be examined. The importance of correct management to the long term health of the diabetic will also be discussed.

CHAPTER 3

Diabetic Management

3.1. Introduction

The treatment of diabetes involves many aspects. The insulin dependent diabetic will need between one and four injections of insulin (refer to section 3.3.) per day using a combination of different types of insulin (refer to section 3.3.2.3.) and a strict limited carbohydrate diet must be followed (refer to section 3.3.3.). Blood and urine tests are taken and the results recorded in a log book or diary and closely monitored. Exercise also plays an important part in diabetic management because blood glucose is used up at a faster rate during exercise. A full explanation of the regime of diabetic management is given in section 3.3.

It is important that good blood sugar control is maintained in order to avoid the immediate and long term problems associated with childhood diabetes. The diabetic typically visits a clinician at the local outpatients clinic at regular intervals where the clinician assesses the information recorded in the diary and advises the parents on any changes of management. For example if blood or urine tests are persistently high he may advise an increase of insulin. However the parents of diabetic children must come to terms with the fact that for the majority of time diabetic management is a problem with which they must cope (Valenta, 1983).

3.2. Insulin

3.2.1. Islets of Langerhans

The cells that produce insulin in man are less than 1% of the total tissue of the pancreas. The cells were called the Islets of Langerhans after their discoverer Paul Langerhans who first observed them in 1869. The Islets are embedded in the general mass of the gland which produces the digestive enzymes amylase, trypsin and lipase.

3.2.2. Structure of Insulin

Insulin has two chains, A and B, which form a stable element by a link through sulphur atoms. An additional ring is formed by sulphur atoms linking together on the A chain. The sequence of amino acids varies from one species to another. There are differences in the three amino acids between the sulphur atoms in the A chain in several mammalian insulins. These differences cause antibodies to insulin to be produced when insulin extracted from one species is injected into another. When the common commercial insulin produced from beef is injected into man, antibodies against this type of insulin will be produced. Except in rare cases, these antibodies do not seem to produce significant resistance to insulin, even though they persist through life.

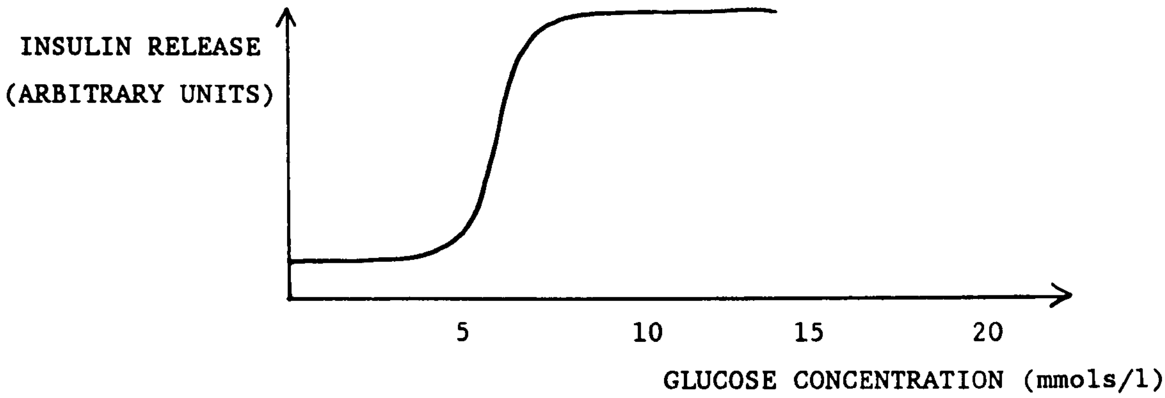
3.2.3. Substances Which Promote Release of Insulin

In the healthy individual, a rise in blood glucose is the most important stimulus for insulin secretion but other substances may promote insulin release by altering the metabolism of the B cells. Amino acids, in particular basic amino acids such as arginine, stimulate insulin secretion and a protein containing meal therefore raises the blood level of insulin.

3.2.4. Mechanism of Insulin Secretion in a Healthy Individual

It is not known how glucose, amino acids or drugs promote insulin release but it is thought that glucose may act in two stages. Firstly an intermediate phase of insulin release beginning within seconds and secondly a later sustained phase of insulin secretion depending on glucose metabolism within the B cells. Insulin release does not respond to blood glucose until it exceeds 5 mmols/l. The B cells of the islets respond rapidly by secreting extra insulin until the level of glucose reaches about 15 mmols/l (see Figure 3).

FIGURE 3 Release of Insulin From Islets in Response to Glucose.



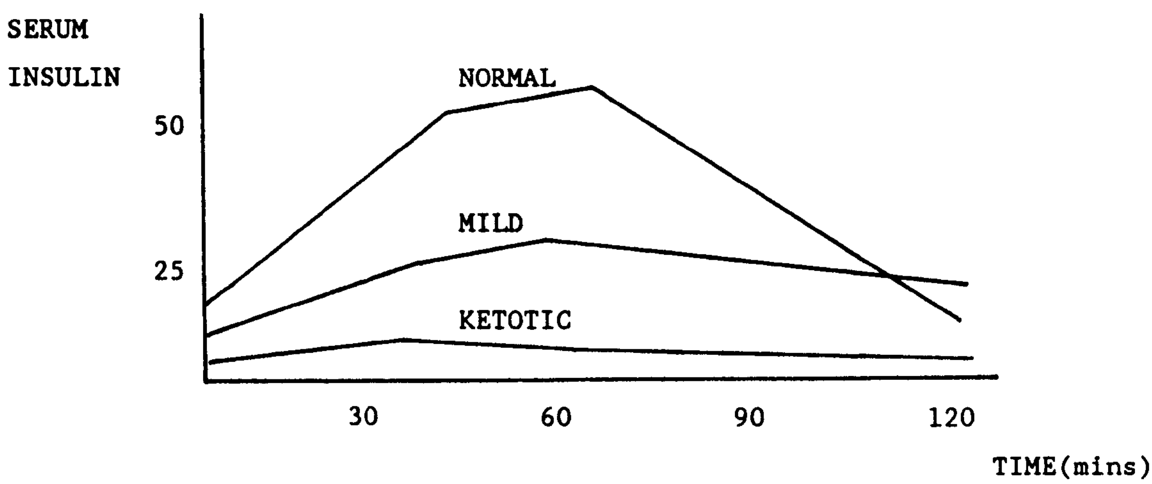
3.2.5. Synthesis of Insulin

Insulin is synthesised via a precursor called proinsulin. It is a single chain of amino acids which is split by enzymes in the pancreas into insulin and the C peptide. These are both released in equivalent amounts into the blood and small amounts of the proinsulin also circulate in the blood.

3.2.6. Measurement of Insulin in the Blood

Modern methods of measuring the amount of insulin in the blood are called radio immunological assay and depends on the displacement of radioactive insulin from an antibody by insulin present in serum.

FIGURE 4 The Insulin Response to Glucose in Normals and Diabetics.



The level of insulin is measured in hospital in order to aid the clinician treating diabetes, especially the newly diagnosed diabetic who may be in hospital to have his condition stabilised.

The serum insulin response to glucose by mouth is shown in Figure 4. The insulin level rises from a low fasting value, to a peak after 30 to 60 minutes and falls back to almost normal by 2 hours. After an intravenous injection of glucose the rise in blood insulin is similar but much quicker, the peak being within a few minutes of the injection. The delay in maximum release after oral glucose is due to the time taken for absorption from the gastrointestinal tract. The total response to glucose by mouth is considerably greater than when it is given intravenously. Other hormones are probably produced in the wall of the gut which may be transported to the pancreas to facilitate insulin secretion. Amino acids taken orally also increase blood insulin levels but the response even with very large quantities of protein is much less than with glucose.

3.2.7. Blood Insulin Levels in Diabetes

The severe diabetic has an absolute insulin deficiency which is the immediate cause of this diabetes, and very little insulin can be extracted from the pancreas after death. Less severe diabetics often possess some circulating insulin though it may not be enough to keep the blood glucose within normal limits. Such patients may respond well to drugs which increase blood insulin by direct effect on the Islets of Langerhans. Referring to Figure 4, the severe diabetic produces no insulin whereas the response of the mild patient is delayed and less than normal.

3.3. Regime of Management

3.3.1. Aims

The main aim of treatment and management of the diabetic is to make the patient well and keep him well. An important part of this treatment is the restoration of normal weight in the adult and the maintenance of normal weight, growth and development in the diabetic child.

It is necessary to control blood sugar to a level that is as close to normal as possible and avoid both hypoglycaemia, too little blood glucose and hyperglycaemia, too much blood glucose. Both conditions are fully explained in sections 3.3.6. and 3.3.7.

The symptoms of diabetes should not only be relieved but good biochemical control should be maintained so that a safety margin is provided preventing minor day to day events, such as injury or infection, resulting in serious diabetic upset. In addition good blood sugar control is necessary to prevent or delay the long term complications of diabetes.

3.3.2. Insulin

Commercial insulin is made from ox and pig pancreas. Both insulins have a slightly different molecular structure to human insulin and therefore diabetics using these insulins develop antibodies. Insulin made from ox pancreas is more antigenic than insulin made from pig pancreas but the tendency of the individual to produce antibodies varies considerably. Most insulin is produced from ox pancreas because its availability is greater than pig pancreas. Antibodies are produced by substances other than the insulin molecule. A number of very pure insulins are commercially available as a result of the removal of these impurities. There are three main groups of insulin available:

1. soluble (regular) insulin
2. intermediate insulin
3. long acting insulin

3.3.2.1. Very Pure Insulin.

Highly purified neutral pork insulin produces significantly less antibodies than beef insulin or mixed preparations of pork and beef insulins of equally high purifications. Pure insulins from ox pancreas cannot be produced.

There are a number of advantages with very pure insulins. It is claimed that there is a lower insulin requirement when given at the beginning of treatment and a reduction in dose when substituted for ordinary insulin (Craig, 1981). It is said that very pure insulins prevent insulin resistance, general or local allergic reactions or lipatrophy. Also, they may have a favourable effect on long term complications.

3.3.2.2. Quantity of Insulin

Juvenile onset diabetics are liable to develop ketosis, resulting from the breakdown of fat (further explained in 3.3.7.), and require large doses of insulin to prevent persistent hyperglycaemia. Generally it is necessary to administer insulin by two injections per day. There are exceptions, however in most cases blood sugar is better and more safely controlled by insulin injected twice daily. Also, it is more likely to prevent severe hypoglycaemia during the night and early morning hours.

The quantity of insulin required by the diabetic varies between individuals but a general guideline is 1 unit of insulin for every kilogram of the diabetic's weight.

3.3.2.3. Types of Insulin

Short acting insulins are used in the treatment of diabetic ketacidosis, (this condition is explained in section 3.3.7.), and as routine therapy in combination with a medium insulin.

Short-medium is neither short nor medium acting, its duration falls between the two.

Medium acting insulins are used to base insulin therapy on. One morning injection may be sufficient treatment for a child in remission (honeymoon period). During this time the symptoms of diabetes will become less apparent or disappear altogether (Craig, 1981). It may last for weeks, months or years but diabetes always returns and insulin requirements will rise and two injections a day will be necessary. When starting two injections per day, the daily total of insulin should be decreased by 10% to 20%, giving two thirds in the morning and one third in the evening.

These general rules are a starting point and subsequent changes may be indicated as necessary by the results of the urine and blood tests. As the diabetic approaches puberty it will most probably be necessary to give twice daily injections of a mixture of short and medium acting insulins. The paediatric custom is to begin with two thirds of each injection being medium acting and one third being short acting. If a child is diagnosed at ten or eleven years old it may be necessary to start immediately with two injections.

Ready mixed insulins are available and avoid the diabetic having to measure both types of insulin. However its doses are not as versatile as separate insulins. Ready mixed insulins tend to be prescribed for diabetics who have problems with mixing doses of different types of insulin.

Finally clinicians will always consider the needs of the individual diabetic rather than rigidly applying the above insulin regimes. The quantity of insulin a diabetic is taking may be adjusted at any time particularly if a particular problem such as recurrent hypoglycaemia occurs. The parents of the diabetic or the clinician may then decide to decrease the morning insulin dose depending on the time of the problem The rules for changing insulin doses is discussed in detail in Chapter 7.

3.3.3. Diet

At the time of diagnosis, while the patient is being stabilised, the dietitian at the hospital will calculate the appropriate diet (Craig, 1981). Limited carbohydrate is the diet most commonly used and the daily carbohydrate intake is measured according to the child's age using the following formula.

(100 or 110) + 10 x age in years = daily requirement in grams.

Thus a seven year old would be allowed 170g to 180g per day. Fat and protein are not measured. The 170g allowance may be divided up into portions of :

Breakfast	30
Snack	20
Lunch	40
Snack	20
Tea	40
Supper	20

These portions may be adjusted depending on the individual diabetic's circumstances.

If a child appears to be continually hungry and is not obese then the carbohydrate allowance may be increased. The type of food, its carbohydrate content and the time to be eaten should be considered for example, foods such as milk (lactose) or fruit (fructose) may have too short an overnight effect on the blood sugar and increase the risk of a hypo before breakfast. A more suitable choice of food would be a more starchy snack such as a sandwich. Recent research has advocated the use of a high fibre/low fat content diet because the rate at which food is absorbed into the blood stream raising its sugar level is decreased. This type of diet, it is suggested, may improve blood sugar control (McCulloch et al, 1985).

3.3.4. Exercise

Exercise may have several effects on blood sugar (Jette, 1984). When strenuous exercise is undertaken the blood sugar is rapidly used up and children are allowed to eat a measured quantity of sweets before participating in any form of strenuous exercise such as swimming. This action is not without its problems within diabetic management. For example, a child may eat sweets before a game of football but if he is the goal-keeper he may not use up the extra carbohydrate, resulting in high blood or urine test results. Although the rules should be applied, the individual circumstances must always be considered.

Another problem may arise due to a specific part of the body being exercised. For example, if the leg is injected with insulin and then the diabetic proceeds to ride his bicycle, the absorption of insulin will be much faster than if he were to inject his leg and then sit down.

3.3.5. Blood and Urine Testing

Blood and urine tests should be taken at least twice and possibly up to four times or more per day (De Meijer & Meinders, 1984) .

Urine tests indicate the quantity of sugar in the urine and it should be zero in a non diabetic but there may be a considerable quantity in that of a diabetic. There are several tests available to indicate the level of sugar present in the urine. Some possible results are:

0	-	no sugar in the urine
1/4%	-	1/4% of sugar in the urine
1%	-	1% of sugar in the urine
2%	-	2% of sugar in the urine

The ideal would be for all the tests to be 0 but this is very difficult to achieve without suffering hypoglycaemia. A clinician may ask the patient to aim for 50% of his test results to be 0. Once 50% had been achieved the next goal may be 55%. All results are recorded in a diary or log book so that the clinician may examine them at the next clinic (Mirouze et al, 1977).

Blood tests have the advantage that they show the present blood glucose level, whereas urine tests indicate previous blood glucose levels (Cohen & Zimmet, 1980). A test is taken by pricking a finger with a sterilized needle to produce a small quantity of blood. A large drop of blood is then transferred from the finger to a special test strip. The colour of the test strip is compared with a colour chart and the appropriate blood sugar result can be read (Tattersall & Gale, 1981).

There are several types of blood glucose tests available (Valenta, 1983) and they are more convenient than urine test methods. However, children may sometimes object to their fingers being regularly pricked to draw blood. The test results may fall into three categories:

0	-	3.9	low
4	-	8.5	normal
8.6	-		high

Both test results may be recorded in the log book for the clinician to examine.

Persistent high test results must be avoided and the clinician or parents should decide on an appropriate change in management, such as adjusting the child's insulin dose if the number of high test results increase.

3.3.6. Hypoglycaemia

Hypoglycaemia (Gorman, 1965) occurs when the blood sugar falls below the lower normal level or insulin levels are rather high (insulin reaction). It is difficult for the well controlled diabetic to avoid occasional attacks because variations in physical activity make it difficult to prevent good blood sugar control falling below normal levels (Maddock & Krall, 1953).

The symptoms of hypoglycaemia may include pallor, sweating, confusion, irritability, headache, hunger or bizarre behaviour. Irritability is a common symptom in young children and also confusion, which means that although the child may know the necessary action to prevent a hypo he may not be able to take some sugar or a sweet at the appropriate time. If the hypo is prolonged because sugar has not been taken, most likely overnight, it may proceed to a coma and vomiting or convulsions. The longer the attack without treatment, the more difficult it is to stop. The shorter acting the insulin the child is being treated with, the shorter the attack.

Although the pattern of the attack will be different for each individual, usually the same pattern recurs for each child. Some children become hypoglycaemic more readily than others, possibly because they do so at a higher level of blood sugar. Some children have more severe attacks than others because they are more sensitive to a given low level of blood sugar (Erlich, 1982).

Hypos may be very sudden and very difficult to treat but usually the attack can be averted by giving 20g of glucose or sugar in a little water. Hypos may also be treated with a sugar lump, glucose tablet or a sweet. If the symptoms do not ease after five minutes then more sugar should be taken. If the child is unable to swallow, then an injection of glucogen should restore consciousness in 15 to 20 minutes.

There are certain times of the day when attacks may be more likely, particularly before a meal. There are a number of actions that may be taken to prevent the problem and they are discussed in detail in Chapter 5.

Sometimes it is difficult to diagnose hypoglycaemia (Sussman et al, 1963, Silas et al, 1981). For example nightmares are an indication of a hypo but not on all occasions. If sugar is administered to alleviate the symptoms but the test results in the morning are very high then it was most probably a normal nightmare. Unfortunately, it is necessary to use a trial and error approach. However, a child should always be given sugar if there is any doubt.

Anxiety attacks in highly strung children may also be confused with a hypo. A child may pretend to have an attack in order to eat a sweet or manipulate his environment. Again the test results following the attack should be helpful. If a child becomes unconscious he should be taken to the casualty department of the hospital. Occasionally the child's sugar level may rise spontaneously, without the administration of sugar, to a normal level but recovery from the coma may be delayed because of the combined action of the body defences, the waning effect of insulin and the re-assertion of the diabetic state.

Repeated severe hypo attacks are an indication of poor control and may result in cerebral impairment, epilepsy or behaviour disorder of the cerebral dysfunction type (Craig, 1981). Very young children are mostly at risk because frequent hypoglycaemia may be missed during their long hours of sleep.

A clinician dealing with hypo attacks at an outpatient clinic will always question the circumstances prior to the attack before deciding to change the child's treatment. For example missed meals may be the cause rather than too much insulin.

3.3.6.1. Somogyi Effect

Sometimes diabetic control may appear to be very poor because of high test results in the morning (Gale et al, 1980). This situation may actually be improved by decreasing the evening insulin dose (Frazier & Neelon, 1984). In this case the morning hyperglycaemia may be due to a rebound (Kiser, 1980) of the hypoglycaemia (Somogyi, 1938), known as the Somogyi Effect.

3.3.7. Hyperglycaemia and Ketosis

Hyperglycaemia is the term used to refer to blood sugar levels being higher than normal. It is unavoidable in the insulin dependent diabetic and may be due to a number of reasons. For example, their insulin dose may be too low or they may have eaten too much carbohydrate. Persistent high test results must be avoided to prevent or delay the long term complications of diabetes. The rules that apply to remedy the condition are discussed in Chapter 7. Hyperglycaemia, if untreated, may lead to diabetic coma and even death (Craig, 1981).

Diabetic coma is due to a considerable excess of sugar in the blood but the accumulation of acetone which occurs at the same time may be equally important. The functioning of the brain is impaired by the excess of sugar and acetone leading to the loss of consciousness. Diabetic coma is very serious and without rigorous and early treatment in hospital, death is inevitable.

Diabetic coma is gradual and is preceded by symptoms of uncontrolled diabetes. Usually there is a loss of weight and energy and the urine contains heavy amounts of sugar and acetone. The coma will only result if diabetes has been out of control with high blood sugar levels and the production of ketones from the breakdown of fat (referred to as ketosis).

An infection such as pneumonia may cause a loss of diabetic control particularly if the diabetic does not eat or take his insulin. The lack of insulin causes ketones to be produced, the blood sugar level rises even though no food is eaten and the patient loses consciousness. The body breaks down fat and protein stores as a source of fuel which produces excessive sugar and ketones. The condition can only be treated with insulin. Diabetic patients, when they fall ill, are advised to maintain their insulin injections and take their carbohydrate in the form of light drinks if they are unable to eat.

Occasionally, the onset of a coma is the first sign of diabetes, particularly in children because the symptoms may have been confused with an infection. Treatment for a diabetic coma is carried out in hospital. The patient will be fed intravenously by replacing fluid, salt and alkalines, and antibiotics may be given to treat the infection.

3.4. Complications

The immediate complications of childhood diabetes, hypoglycaemia and hyperglycaemia, have already been discussed. The longer term complications of diabetes are rare before puberty. Mild forms of retinopathy and albuminuria can occur and also diabetic cataract which may remain stationary or mature rapidly despite good blood sugar control. It is unknown how important early control is on the later development of complications.

3.5. Education

3.5.1. National Health Service

When a child is diagnosed a diabetic he may be admitted to hospital for his condition to be stabilised. Sometimes, particularly if the condition has been identified at an early stage, a hospital stay is unnecessary. However the initial education will be given by the clinician. The main information will comprise of:

1. The effect of insulin lack on the blood sugar
2. The interaction of food, insulin and exercise on the blood sugar
3. The cause, timing and treatment of hypos
4. Injection sites, syringes, insulin
5. Occasions for lowering or raising insulin
6. The action to be taken if a child develops an infection

The diabetic will visit the paediatric outpatients clinic at regular intervals where his diary will be examined by the clinician. If particular problems arise such as recurrent hypoglycaemia he may advise a decrease in insulin. Whatever his advice may be, he will then proceed to explain why such an action is necessary.

Booklets (Kinmonth et al, 1982) will also be available at the clinic (Essig, 1983). If the child is not admitted to hospital or when the child arrives home, the health visitor will visit the child's home frequently until the parents are used to coping with the situation.

The dietitian will work out the child's carbohydrate allowance and give advice on suitable recipes at the paediatric outpatients clinic.

3.5.2. British Diabetic Association (BDA)

The BDA supplies further books and pamphlets on the care of diabetes. It also publishes a monthly newspaper (Balance) with interesting articles, recent research, problem page etc. Regular meetings are held with guest speakers.

One of their main activities to help educate children are the BDA summer camps. The camps are held all over the country and diabetic children attend for two weeks. The aim is to encourage the children to meet other diabetics and learn about their condition. The staff keep a careful eye on their treatment and may change the insulin dose or diet. Children not already administering their own injections are encouraged to do so but the emphasis is on fun and sporting activities.

3.5.3. Recent Research

New methods of education for the diabetic involve a more logical approach (Falkenberg, 1983) for example, Skyler et al (1979, 1981) devised a set of algorithms to be used by the diabetic. The algorithms are printed on sheets of paper and do not explain their advised action.

The advent of the widespread use of computers in school and at home has promoted the use of computers in the field of diabetic education(Mazze &

Zimmet, 1987, Wise 1987) . They allow highly motivated diabetics to learn about their condition using a computer program rather than a book (Cook, 1982, Levy et al, 1987,Morrisett, 1984, Rodbard et al, 1984).

3.6. Summary

In order to maintain good blood sugar control the parents of diabetic children must know and understand a large amount of information (Korhonen et al, 1983, McNeal et al, 1984, Pickert, 1983, Prater, 83). It is a particular problem for the parents of the newly diagnosed child who may be coping with the emotional stress of caring for a sick child. However, the rules of diabetic management must be learnt and understood quickly to avoid both immediate and long term problems associated with diabetes. Although education in this area is provided, continuous support for parents in the home would be of value.

Computers are already available for the role of diabetic education. However it may be of further and more valuable use if the computer program could be tailored to the individual child. The guidelines for diabetic management are well documented (Anderson, 1983) but in practice it is essential that the circumstances of the individual are considered before a management regime is altered, for example, changing the diabetic's insulin dose.

It seems appropriate that a home based computer system to aid diabetic management for the individual child, providing continuous support for parents and providing a source of education may be feasible.

It is appropriate at this stage to examine other aids for diabetic management.

CHAPTER 4

Appraisal : Methods and Aids for Improving Blood Sugar Control

4.1. Introduction

Diabetes is a very complex condition to manage because many, often unpredictable, factors affect its management, for example, exercise (Ginsberg & Fink, 1983). The aim of management is to maintain the diabetic in good health and try to avoid the long term complications. Although the diabetic visits the clinician regularly, he is encouraged to control his/her own day to day blood sugar levels. There is a considerable amount of information to be learned and guidelines to be followed (Skyler et al, 1979). Consequently many attempts have been made to devise aids (Mashima & Nomura, 1986) to help diabetic management (Schmitt et al, 1980).

Electronic devices have been developed allowing greater accuracy of blood test reading and are described in section 4.4.

One of the main problems with insulin treatment is that injections are administered twice daily, whereas the insulin level in a non-diabetic is adjusted naturally according to the blood sugar level. The insulin infusion pump administers small quantities of insulin throughout the day and there are several versions available. Insulin infusion pumps are discussed in section 4.3.

One of the main aims of diabetic management is that blood sugar levels must be kept as low as possible without too many attacks of hypoglycaemia (Varma, 1979). Several devices are available which attempt to detect hypoglycaemic episodes before they become serious and are discussed in section 4.5.

Computer systems to aid general diabetic management are being developed in the form of large systems and programs designed for personal computers. These are described in sections 4.6. and 4.7.

Each of the aids discussed in this chapter has both advantages and disadvantages.

Although the devices discussed may be helpful the special needs of one particular group of diabetics have been largely ignored and are identified in section 4.8.

4.2. Traditional Methods

The traditional method for aiding diabetic management is the diabetic log book or diary completed by the diabetic or, in the case of children, by the diabetic's parents. There are many different formats in which the information is recorded (see example below).

FIGURE 5 A Diabetic Diary

DATE	CARBOHYDRATE	INSULIN	TESTS	NOTES

The book is presented to the clinician at regular intervals. The clinician examines the number of high blood or urine test results and tries to identify any problem areas. With further questioning, the clinician advises the diabetic on a particular course of action necessary to prevent certain problems. For example, a patient suffering persistent high test results in the evening may be advised to increase the quantity of insulin.

4.3. Insulin Infusion Pumps

Insulin infusion pumps are small battery operated electronic machines which allow small quantities of insulin to be administered to the diabetic throughout the day. It is claimed that this method of administering insulin is preferable to two injections per day because the infusion pump mimics the normal production of insulin more closely (Blackshear, 1982). The non diabetic produces small quantities of insulin automatically and continuously depending on the blood sugar levels whereas the diabetic taking two injections of insulin is taking his total insulin requirement in two large quantities. The rate at which insulin disappears cannot be altered to suit the sugar level in the blood.

The infusion pump is a small battery driven syringe pump which may be instructed to deliver insulin at different rates (Theveriot, 1982). The insulin is delivered via a fine nylon cannula implanted subcutaneously in the anterior abdominal wall and the machine is attached to a waist belt.

Clinical trials testing such machines have concluded that insulin infusion pumps increase the blood sugar control of the diabetic (Pickup et al, 1987, Pickup et al, 1983, Tamborlane et al, 1983). These devices are not generally available on the NHS and are expensive for the individual to buy. They are unsuitable for the normal boisterous nature of children.

4.4. Blood Glucose Meters

When a blood sample is tested for blood sugar, the test strip holding the sample has, after a specified period of time, to be matched up to a colour chart on the test strip container (Cohen & Zimmet, 1980). Each shade of colour represents a level of blood glucose which is labelled beneath the colour shade (Sonksen et al, 1980, Warzak et al, 1982). It can be quite difficult to match up the test strip with the correct shade due to the similarity of the colour shades (MacDonald & Standring, 1983).

Electronic machines are available for reading the blood glucose level automatically (Borthwick & Ross, 1979). The reading is displayed digitally giving an accurate reliable indication of the blood sugar level. More sophisticated machines also store the result in the memory and display the information when requested (Smith et al, 1985).

These devices play an important part in diabetic management because the test reflects accurately the quantity of sugar in the blood (Sonksen, 1980, Sonksen, et al, 1978, Sonksen et al, 1980). Providing the user is highly motivated the diabetic can respond to the results with the appropriate action if necessary. For example, a diabetic may suspect he is becoming hypoglycaemic but may choose to test his blood sugar levels before taking some glucose. Obviously this course of action may prevent the diabetic taking glucose unnecessarily and thus avoiding unnecessary high blood sugar levels (Baumer et al, 1982). The apparatus is unfortunately difficult for children to use (Craig, 1981, Smith et al, 1985) due to the timing precision required to operate the machine.

4.5 Hypoglycaemia detectors

4.5.1. Introduction

Hypoglycaemia occurs when the blood sugar level dips below the normal lower level and there is a quantity of insulin in the blood (Gale, 1980) It has a detrimental effect on diabetic management because in order to stop the symptoms, a quantity of sugar must be eaten. Consequently, during the period after hypoglycaemia, blood sugar levels are often at a higher than 'normal' level (Pfeiffer et al, 1976).

Hypoglycaemia is difficult to recognise because of the wide variation in symptoms and sometimes the absence of symptoms. Night time hypoglycaemia is a particular problem (Yoshizawa et al, 1979) because it may be completely unrecognised and therefore unrecorded in the diabetic's log book (Gale, 1980).

Hypoglycaemia during the day time and especially at night is a particular problem for children. Their unpredictable activity levels and changing developmental status makes the quantity of insulin to be administered difficult to judge, resulting in the child suffering hypoglycaemia perhaps more frequently than adult diabetics.

Some parents use an ordinary baby's listening system in order to listen for their child's symptoms of night time hypoglycaemia. It has been documented that restlessness and stertorous breathing (Gale, 1980) indicates hypoglycaemia but these symptoms may be confused with the symptoms of a nightmare. If the child is woken at this time it may be possible for the parents to deduce whether hypoglycaemia is present.

Another indicator of hypoglycaemia is sweating but not all hypoglycaemic diabetics display this symptom. However a bedwetting alarm system, designed for the purpose indicated by its name, when detecting moisture, sets off an audible alarm. This device may be used to detect moisture from the sweating child which may indicate that the child is suffering from hypoglycaemia . Unfortunately the alarm may be triggered by thermal sweating.

Several purpose built electronic devices have been designed to detect hypoglycaemia at an early stage, warning the diabetic by triggering an audible alarm.

4.5.2. Diabalert

The Diabalert (Alric et al, 1980) is a portable battery operated device which detects skin conductivity. Sweating, perhaps induced by hypoglycaemia increases skin conductivity and therefore reduced galvanic skin resistance. If the increase in skin conductance reaches the pre-set threshold an alarm is set off, warning the diabetic that hypoglycaemia may be present.

Preliminary tests carried out at Guy's hospital, London (Pickup, 1982) proved inconclusive. The number of false positive occurrences was a particular problem because sweating may be due to many reasons other than hypoglycaemia.

4.5.3. Teledyne Sleep Sentry (T.S.S.)

The T.S.S. developed by Teledyne Avionics, U.S.A. measures both temperature and skin conductance (Levandoski et al, 1981). During hypoglycaemia, body temperature may decrease (Gale, 1980) while skin conductance may increase. Using two combined indicators of hypoglycaemia may improve the accuracy of correctly detecting hypoglycaemia. However, during trials on juvenile diabetics, a large proportion of documented episodes of hypoglycaemia were detected but the frequency of false positive alarms were more than three times the number of correct alarms (Hansen & Duck, 1983).

4.6. Computer Systems

Several computer systems have been designed to provide aid for diabetic management (Newman, 1987, Mazze & Zimmet, 1987, Wise, 87, Wise et al, 1986), ranging from data capture systems to programs advising on insulin adjustment (Albisser et al, 1986, Hovorka et al, 1990, Meadows et al, 1988, Schiffrin, 1988).

4.6.1. Data Capture Systems

4.6.1.1. DIADATA

Diadata (Day, 1983) is a hospital based micro computer system which services several hand held micro computers which are used in the home of the diabetic. The slave collects the every day diabetic information which would normally be recorded in a diabetic log book or diary. The slave is taken to the outpatients clinic where printouts are obtained from the master machine. The data is printed out in a simple form similar to the log book and simple data analysis and graphical displays are also produced.

4.6.1.2. DIABAID

Diabaid developed in Erpic, France (Allouche et al, 1983) also consists of a hand held micro computer used in the home of the diabetic. It collects diabetic information that is normally recorded in the diabetic diary. The machine is taken to the diabetic clinic, at regular intervals where the information is printed out. The information is also transferred to the national database devoted to epidemiology research.

The system was developed to improve information transfer between the diabetic and clinician and from the clinician to the national database.

4.6.2. Management Advice Systems

4.6.2.1. DIABETA

The staff at St Thomas's Hospital, London (Boroujerdi et al, 1987a, 1987b) is currently developing a rule based system to aid general practitioners with the management of diabetes (Brown, 1985). The system is being developed to cope with the possible transfer of the care of adult diabetics to the G.P. However, G.P's are not diabetic specialists, and it is proposed by the Hospital that a dedicated micro computer, holding thousands of diabetic management rules, formulated by specialist clinicians may be used by the G.P. to complement his skill in patient care. The system specification indicates that it is solely for the use of the G.P. providing data capture facilities and utilising the rules of diabetic management.

The development cost of this project is in excess of £100,000. This figure excludes the cost of the intended large scale implementation, in particular, the purchase and installation of machines and costs of training the G.P.

4.6.2.2. Insulin Dosage Computer

A purpose built hand held Insulin Dosage Computer (I.D.C.) has been developed and is currently being used by 300 diabetics (Albisser, 1987a,1987b). It advises patients on their daily insulin requirements by analysing blood or urine test results and applying insulin dosage algorithms (Skyler et al, 1981, Albisser & Shultz, 1986).

The facilities offered by the I.D.C. include data capture of blood or urine tests, advice on the correct insulin dosage and printouts of the test results can be obtained at the diabetic clinic. The system assumes that the diabetic has a consistent lifestyle and predictable activity levels. In addition, it is assumed that the food plan is followed closely.

The clinician at the hospital programs the targets for the blood or urine test results. If the tests rise above the target then the system will advise on an increase in insulin. The advice is based on a diabetic using a multiple component regime of insulin (Schiffrin et al, 1985).

The I.D.C. aims to assist in customising diabetic management and to assist the clinician in solving the problem of dosage titration to achieve and maintain a level of control specifically adapted to each patient (Albisser, 1987b).

4.6.2.3. Basic Program for Insulin Dosage Advice

A program has been developed to provide a consultation system for self adjustment of insulin (Pernick et al, 1983). The BASIC program, designed for the IBM-PC, aims to educate patients, physicians and paramedical personnel with the self adjustment of insulin therapy in conjunction with home glucose monitoring (Rodbard et al, 1984).

The program is based on a set of algorithms (Skyler et al, 1981) and gives advice when it is necessary to increase or decrease insulin doses.

Additional features include data capture, data printouts and graphical displays. The system is currently used in the hospital as an educational tool for the staff caring for diabetic patients. This system is aimed particularly at adults and it is not clear whether the system will cater for the varied activity levels of a diabetic child.

4.6.2.4. DIABETES - An Expert System for Education in Diabetes Management

DIABETES (Ambrosidou & Boulton, 1988) is an expert system designed to aid the clinician in diabetic patient care. The system has been designed for the education of medical staff on the diagnosis, treatment and complications of diabetes (Amdrosidou et al, 1988). The knowledge base contains knowledge on insulin dependent (Type I) diabetes and non insulin dependent (Type II) diabetes.

The system runs on an IBM PC/compatible microcomputer and is written in TURBO PROLOG. The pop up menu interface was developed using the TURBO PROLOG Toolbox (Ambrosidou, 1989).

4.7. Discussion

It is recognised that good blood sugar control is sometimes difficult to maintain (Judd & Sonksen, 1980) and consequently there have been many attempts to provide aids for diabetic management.

Insulin infusion pumps attempt to revolutionise diabetic treatment by mimicking normal insulin production. However, such machines will not be suitable for all diabetics.

Some patients may find two injections per day preferable to the infusion pump. It is largely unsuitable for children because of their unpredictable activity levels and sometimes boisterous behaviour.

Blood glucose meters allow the advantage of more accurate readings of blood sugar but does not necessarily mean good blood sugar control will follow since this depends on reacting correctly to low or high readings.

Devices designed to indicate hypoglycaemia are theoretically advantageous but it seems they will be of little use because the symptoms of hypoglycaemia are ambiguous. Clinical trials of these devices suggest that greater accuracy is necessary for any advantage related to diabetic management.

Data collection systems such as DIADATA collect diabetic information that would otherwise be recorded in a diabetic diary. These systems may provide a means for clinicians to identify management problems but they do not have built in knowledge and cannot provide advice on how to remedy a particular problem. It might be suggested that data collection systems are designed for the clinician with less importance attached to the diabetic. All the functions performed are for the general rather than the individual diabetic and do not consider the special needs of the diabetic child.

There are several management systems in existence. St Thomas's Hospital designed a system to aid G.P's managing diabetic patients. The project fails to recognise that day to day care is managed by the diabetic. In addition, each diabetic has an individual management regime and it is not clear whether the proposed system will be able to adapt to the individual. The cost effectiveness of such a system is debatable when considering that it will require high expenditure by the National Health Service to provide non-essential equipment for one group of patients.

The I.D.C. makes a number of assumptions when giving advice on the adjustment of insulin doses which could lead to an instruction for insulin adjustment, when perhaps the problem occurred due to unpredictable exercise e.g. running to catch a train.

The I.D.C. system depends on the clinician setting a target for the blood or urine test results at the clinic. The target is used to give advice and remains constant until the next clinic, possibly leading to persistent problems if the target has been set too low or too high.

Neither system gives an explanation for the advice, and help facilities are not provided. They cannot consider whether previous advice was correct, such backtracking would be an important and sophisticated feature to prevent escalating insulin doses.

The I.D.C. does not allow patients to record both blood and urine test results and the computer program allows blood tests only. It is unclear how versatile each system is in its ability to cope with different types and brands of insulin.

Neither the I.D.C. nor the program caters for the special needs of the insulin dependent child whose changing developmental status and unpredictable activity levels make blood sugar control a difficult task.

4.8. Conclusion

Although many of the systems offer some advantages, a common area that seems to be completely avoided by all the software/hardware is the special needs of juvenile diabetics. It is precisely this group of insulin dependent diabetics that have increased problems with maintaining good blood sugar control. The unpredictable activity levels and changing developmental status of the juvenile diabetic makes their management a complex task. Further, since their condition is not, in the foreseeable future, going to disappear, they will be most at risk from the long term complications of diabetes.

Parents of newly diagnosed diabetic children, while coping with the emotional stress of caring for a sick child, must also come to terms with their child's condition and learn to operate a complex control strategy.

Although the children will visit the diabetic clinic at regular intervals, day to day management must be provided by the parents. If the management regime of the child is not adjusted promptly when, for example, blood sugar tests are persistently high, then the child is at risk of suffering the long term complications of diabetes.

It is therefore appropriate to consider a management system that is suitable for children and their parents to use and is able to cope with their special management needs. The system must be easy to use, reliable and provide a certain degree of diabetic education for both the parents and the child. Such a system is the basis of the research described in this thesis.

CHAPTER 5

Computer Aided Decision Support

5.1. Introduction : Computers in Medicine

Chapter 4 introduced the concept of using a computer to aid the management of the diabetic child and it is therefore appropriate to consider the general role of computers in medicine. Their applications have been utilized in all aspects of medical care and administration.

Many applications involve routine uses such as patient records. Hospitals and clinics are required to store vast quantities of patient information. Easily accessible, reliable patient information is particularly important when patients are on multiple drug treatment . In addition hospitalised patients often require a host of laboratory tests. Computerised laboratories offer both economic and practical benefits to perform routine laboratory tests.

An area in which computer hardware plays a critical role is patient monitoring. A patient in an intensive care or therapy unit may require parameters such as E.C.G. to be monitored . Computers are used for cardiac monitoring of patients of all ages including the newborn (Perlstein et al, 1976). If there is an abnormality in the E.C.G., the medical staff are alerted.

Advanced automated instrumentation techniques such as computed tomography directly processes information captured by means of X-ray, referred to as a C.T. scan. A C.T. scan is a picture of a narrow slice of tissue which is imaged from multiple angles (Ambrose & Hounsfield, 1973) and has the ability to yield more information with less ambiguity than an ordinary X-ray. The generated scan may be processed by a program to improve its diagnostic power (Huang & Wu, 1976).

Computers are used in medical education at both patient and clinician level. Medical undergraduates use computer programs as part of their degree course (Murray et al, 1977).

A rapidly expanding and exciting application of computers is in problems of medical decision making and diagnosis (Blum, 1986,de Vries & de Vries Robbe, 1985, Expert System User, 1989 a, Williams et al, 1988). Decision making is a crucial and difficult part of practical medicine because the patient may present symptoms similar to those of several diseases (Matsumara, 1986). In addition, a number of treatments and drugs may be available to treat a single disease and the most appropriate must be chosen for the individual patient (Wigertz, 1986).

Computer aided medical decision support (Kohout et al, 1986) and diagnostic systems aim to enhance the skill of the clinician (De Dombal, et al, 1986). These diagnostic and decision support systems typically rely on two different approaches. Statistical systems (De Dombal et al, 1972, De Dombal, 1980) are probabilistic, usually depending on Bayesian Theory, whilst expert systems seek to utilize expert knowledge in rule bases (Shortliffe & Davis, 1975).

This chapter considers the different approaches to such decision support systems and their role in improving healthcare. The software tools that are available to build such systems are also considered.

5.2. Medical Decision Support Systems

5.2.1. Computer Aid for Medical Decisions and Diagnosis

In the 1950's it was recognised by physicians and computer scientists that computers could assist with clinical decision making (Libkin & Hardy, 1958). At this time medical diagnosis was analysed with the view to the potential role of automated decision aids in that domain (Wagner et al, 1978).

Due to the rapid growth of medical knowledge, clinicians tend to specialise and become more dependent on assistance from other experts when presented with a complex problem outside their own area of expertise. The general practitioner who first sees the patient has thousands of tests available with a wide range of costs and potential benefits. The clinicians working in a specialised field may reach very different decisions regarding the management of a specific case (Yu et al, 1979 b). Diagnoses that are made, on which therapeutic decisions are based, have been shown to vary widely in their accuracy (Garland, 1959, Prutting, 1967, Rosenblatt et al, 1973). Medical students usually learn about decision making in an unstructured way, largely through observing and emulating the thought processes they perceive to be used by their clinical mentors (Kassirer and Gorry, 1978).

There are numerous motivations for attempting to understand and automate the process of clinical decision making:

1. Firstly, for the improvement of the accuracy of clinical diagnosis through approaches that are systematic, complete and able to integrate data from diverse sources.

2. By making the criteria for decisions explicit and therefore reproducible, the reliability of clinical decisions is improved because unwarranted influences of similar, but not identical cases, are avoided.

3. The cost efficiency of tests and therapies are improved by balancing the expenses of time, inconvenience or funds against benefits and risks of definitive actions.

4. The understanding of the structure of medical knowledge is improved and techniques are developed to identify inconsistencies and inadequacies in

that knowledge.

5. By improving the understanding of clinical decision making, medical teaching is improved and computer programs will be more effective and easier to understand.

Computer systems may base their clinical advice on a range of models from data intensive, to knowledge intensive approaches and they are described below.

5.2.2. Knowledge Engineering and Medicine

5.2.2.1. Decision Support Methodology

There are several prominent methods that form the basis of computer aided decision making and diagnosis:

1. Clinical Algorithms

2. Data Bank Analysis

3. Mathematical Models

4. Pattern recognition and Bayesian Analysis

5. Decision Theory

6. Symbolic Reasoning

Some methods are more suited than others for particular applications (Ramsey et al, 1986). Each method is described below and their advantages and disadvantages are identified.

5.2.2.2. Clinical Algorithms

Clinical algorithms (Essex & Sorlie, 1979) are flow charts to which a clinician can refer when deciding how to manage a patient with a specific clinical problem (Sherman et al, 1973). Algorithms allow decisions to be made by carefully following the simple branching logic. They are one of the most widespread and accepted decision aids but the simplicity of their logic means the technique cannot effectively be applied in most medical domains due to their complexity. Decision points in the algorithm generally depend on a 'yes or no' answer and there tend to be many circumstances that can arise for which the user is advised to consult the supervising physician (Shortliffe et al, 1979).

5.2.2.3. Data Bank Analysis for Prognosis and Therapy Selection

Computerised medical record keeping and computer based patient data banks have been major research concerns. The early systems were designed to keep records but more recently programs have been included in such systems to provide analysis of the information.

ARAMIS (Fries, 1976) is a system based on these methods and was originally designed for use in an outpatient rheumatology clinic but later broadened to a general clinical database system (Weyl et al, 1975) for use in clinics specialising in several diseases including cardiology. All clinic records are kept in a large tabular format regularly maintained at each patient clinic visit and transferred to the computer.

The information in the data bank can be used to create prose summary of the patient's current status and graphical facilities able to plot a patient's specific parameters over a period of time. However its greatest potential utility is the analysis of stored clinical experience. ARAMIS offers a prognostic analysis for a new patient when a management decision is to be made.

Data acquisition is a major problem with these systems because direct physician-computer interaction has been avoided by many system developers and this has led to expense and errors in transcription.

5.2.2.4. Mathematical Models of Physical Processes

Mathematical formulas may be used to describe patho-physiological processes in a limited number of clinical problem areas. This approach to computer based decision aids has been used in applications such as respiratory care (Menn et al, 1973).

The computer program requests the relevant data, makes the appropriate computations and provides clinical analysis or recommendation for therapy.

Bleich developed a program based on this technique for the assessment of acid-based disorders and later expanded it to consider electrolyte abnormalities (Bleich, 1971). However, it is essentially a complicated clinical algorithm interfaced with mathematical formulations of electrolyte and acid-based pathophysiology. Therefore its weakness, as in all algorithmic approaches, is its highly structured and inflexible logic which cannot contend with unforeseen circumstances not specifically included in the algorithm.

Boroujerdi, at St Thomas's Hospital, London, is developing a combined glucose and insulin model to simulate plasma glucose profiles over a period of time (Boroujerdi et al, 1987 b). The aim is to utilize this approach for planning insulin regimes and it will be used within the DIABETA system described in chapter 4.

5.2.2.5. Statistical Pattern-Making and Bayesian Statistical Approaches

Pattern recognition techniques define the mathematical relationship between measurable features and classifications of objects (Duda & Hart, 1973). The presence or absence of each of several signs and symptoms in a patient may be definitive for the classification of the patient as abnormal or into a category of a specific disease. Pattern recognition techniques are used for prognosis (Armitage & Gehan, 1974) or predicting disease duration, time,course and outcomes.

To find the diagnostic pattern a set of objects must be trained and the correct classification must be known as well as reliable values for their measured features. In parametric techniques the parameters of the probability density functions are learned and in nonparametric techniques no assumption is made about the form of the distributions. After training is completed, the pattern can be compared to new unclassified objects to aid in deciding the category to which the new object belongs.

There are a number of medical applications using the techniques of pattern recognition but there are numerous problems associated with the approach. It is difficult initially to choose a set of features, collect reliable measurements on a large sample, and verify the initial classifications among the training data.

Often the assumptions in medical domains are violated but some difficulties are avoided in systems that integrate human and machine capabilities into single, interactive systems (Shortliffe, 1979).

The Bayesian approach to computer aided medical decision making potentially offers an exact method for computing the probability regarding the frequency with which these observations are known to occur for specific diseases.

This technique has been shown to be very accurate (De Dombal et al, 1986) but there are several limitations to this approach, such as the large amount of data required to determine all the necessary conditional probabilities to be obtained. Assumptions must be made, for example, the diseases under consideration are assumed to be mutually exclusive and exhaustive. In addition, the clinical observations are assumed to be conditionally independent over a given disease and the model does not allow for changes in the disease patterns over time. The independence assumption can, however, be relaxed to model specific associations between the clinical observations (Morton et al, 1984).

5.2.2.6. Decision Theory Approaches

Decision analysis is an attempt to consider values associated with choices, as well as probabilities in order to analyse the processes by which decisions are made or should be made. The decision making process can be seen as a sequence of steps in which the clinician selects a path through a network of plausible events and actions. There are two types of nodes in the tree shaped network. Firstly decision nodes where the clinician must choose from a set of actions and secondly, chance nodes which are a probabilistic response of the patient to some action taken. By analysing a difficult decision process before taking any action it may be possible to delineate in advance all pertinent chance and decision nodes, all plausible outcomes, plus the paths by which these outcomes might be reached. Also data may exist to allow specific probabilities to be associated with each chance node in the tree (Teather et al, 1974).

In practice physicians make sequential decisions based on more than the probabilities associated with the chance node that follows and anticipated costs (e.g. financial expenditure, complications discomfort, patient preference) can be associated with the decision nodes. Using all this information an expected value for each pathway through the tree can be calculated. The ideal pathway is the one maximising the expected value.

Obtaining the physicians and patients costs and values is a difficult problem since formal analysis requires costs in standardised units. Overlapping and coincidental diseases are not well managed unless specifically included in the analysis. Gorry et al developed a program for the management of acute renal failure (Gorry et al, 1973) but pointed out that the program was incapable of recognising circumstances where two or more actions should be carried out.

5.2.2.7. Intelligent Knowledge Based Systems (I.K.B.S.)

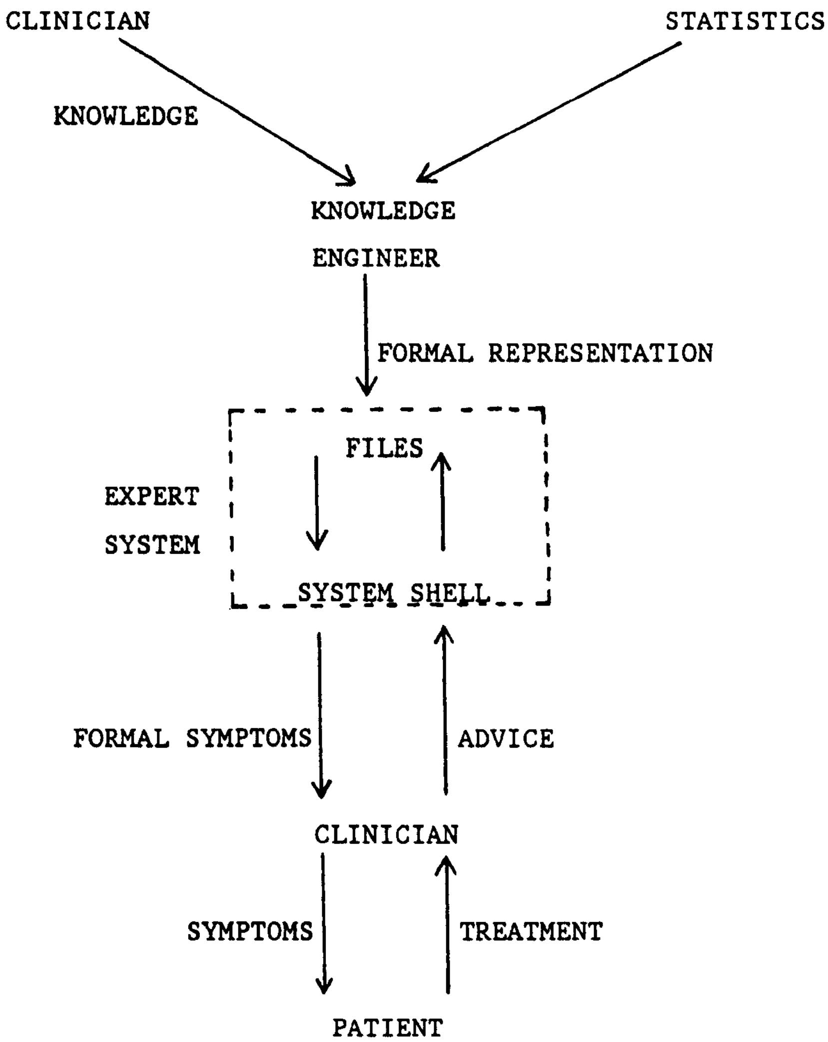
5.2.2.7.1. Overview

At the forefront of current research lies Intelligent Knowledge Based Systems (Duda & Shortliffe, 1983).

IKBS basically consist of a knowledge base, a rule base, and a system shell which allows the information to be utilised (see Figure 6).

Knowledge and rules are acquired from the expert by the system designer or knowledge engineer. In this case the expert is the physician, and the information may be formal, or medical records will be examined. In addition, subjective knowledge and 'rules of thumb' must also be utilised in some cases. Statistical information may also be available (Shortliffe, 1976). The knowledge engineer must be able to use the information and express it in a form the computer system may utilize. Knowledge may be in the form of formal rules and will be stored in files to be used by the rule based system (Davis and King, 1977). Rules and knowledge are never included as part of the program so changes and additions may be made later (Kulikowski, 1980).

FIGURE 6 Diagrammatic Representation of IKBS



5.2.2.7.2. Symbolic Reasoning

Many IKBS's use the symbolic reasoning approach which utilize qualitative experimental judgement codified in rules of thumb or heuristics. The heuristics concentrate the reasoning program on parts of the problems that seem most critical and parts of the knowledge base that seem most relevant. The application of the domain knowledge is guided by deleting items from consideration as well as focusing on items. These programs pursue a line of reasoning rather than following a sequence of steps in a calculation.

The knowledge base of such systems is in the form of a set of rules e.g.

if B and C and D are true, then conclusion is A

The above rule states that A can be reduced to sub-problems or sub-goals B, C and D. A can only be concluded when its sub-goals have been satisfied according to the stated rule. To solve problem A, which is the original goal, it must be restated in terms of other sub-goals.

When, for example, a patient diagnosis is requested, diagnosis is based on that patients record and rules in the knowledge base for evaluating data in a patient record. Each rule in the knowledge base proposes a conclusion which can be asserted if the predicate associated with the conclusion is true. The predicate is an expression consisting of one or more sub-goals. Each sub-goal in a predicate is tested by attempting to match the sub-goal to either a fact in the database or a rule in the knowledge base. If a sub-goal matches a rule, then the problem solver will attempt to verify the conclusion asserted by it. If a sub-goal matches a fact, it is validated immediately. If all sub-goals verify, the original conclusion is validated.

The conclusion asserted by the rule may contain variables when a sub-goal matches a rule. Such variables can receive values from the matching sub-goal and it is called instantiation. The values received from the matching sub-goal are used to validate the matched rule's predicate. Otherwise a sub-goal may contain variables which the matched rule may instantiate.

If given a specific diagnosis and a specific patient, the problem solving program will test the conditions for the named diagnosis with the patient name given. The problem solver asserts an instance of the named diagnosis for the instantiated patient, if each condition or sub-goal in the rule validates. The problem solving program may also be given a specific diagnosis and asked to find the identities of all patients for whom the predicate associated with the diagnosis is true. In this case the problem solver supplies values for the variable rather than receives them.

5.2.2.7.3. Scope and Limitations

Both INTERNIST (Pople et al, 1975) and MYCIN (Shortliffe, 1976) are examples of programs using this technique. INTERNIST can diagnose simultaneous diseases and pursues all abnormal findings to completion even though a clinician often ignores minor unexplained abnormalities if the rest of the patient's clinical status is well understood. MYCIN, although never implemented for routine clinical use, was shown to reach decisions at the level of an expert during formal experiments (Yu et al, 1979a, 1979b).

Some programs utilising symbolic reasoning techniques mimic the reasoning styles observed in experts (Elstein et al, 1978, Kassirer and Gorry, 1978), but it is not clear how to prevent the systems abandoning one hypothesis and turning to another when new information suggests another possibility. Symbolic reasoning is not utilised within all IKBS's. A combination of symbolic reasoning and other approaches may be required.

5.3. Operational Decision Support

In section 5.2.2. the two most important approaches to the decision support have been described. These approaches are usually referred to as the Bayesian and rule based approaches.

Four operational systems can now be described in detail to illustrate both early and more recent applications of these two techniques.

De Dombal's system to aid the diagnosis of acute abdominal pain is one of the first systems based on Bayes' Theory and one of the latest, most sophisticated systems is BRAINS (Teather et al, 1985). Both are described in the following sections.

INTERNIST (Myers et al, 1982) was one of the earliest rule based systems while MYCIN (Shortliffe, 1976) is a widely used rule based system forming the basis for other decision support systems.

St Thomas' Hospital London is currently working on a rule based system to aid the G.P. in the care of adult diabetics and it is described in section 5.3.5.

5.3.1. Computer Aided Diagnosis of Acute Abdominal Pain

A program was developed at Leeds University to perform diagnosis of acute abdominal pain. The program was written in Fortran and based on Bayes' Theorum (De Dombal et al, 1972, De Dombal et al, 1984).

To obtain a 'diagnosis' an entry is made in a queue of jobs requesting the running of a compiled program. The program performs the Bayesian analysis on previously entered patient data and prints out, on the terminal, the probabilities and information as requested.

Specialized forms were completed prior to requesting a diagnosis. The information gathered on the form included symptoms such as the severity of the pain experienced by the patient. The forms allow 'formulation' of the symptoms so that they may be entered into the computer.

The patient is assigned, by the clinician, a category of possible diseases. When the program runs, it selects the appropriate database about this class of diseases, performs Bayesian analysis and stores the resultant case probabilities. A hard copy of the patient's case history is included with the possible diseases and their probabilities (De Dombal et al, 1972).

The system aims to enhance the clinician's skill in diagnosis by providing him with accurate statistical analysis of large volumes of data relating to acute abdominal pain.

An initial evaluation study carried out at Leeds University concluded a margin of performance in favour of the computer aided system (De Dombal, et al, 1972).

A controlled trial of human and computer aided diagnosis involving 552 patients with acute abdominal pain was carried out at a later date. The overall diagnostic accuracy of the computer aided system was 91.5% and that of the senior clinician to see each case was 81.2% and the clinician's performance during the trial improved (De Dombal et al, 1974).

The system has since been upgraded and its knowledge base increased. Further studies have indicated its benefit as a diagnostic aid (Adams et al , 1981, De Dombal et al ,1986).

5.3.2. BRAINS

BRAINS is a computer advisor system to aid in C.T. scan interpretation and cerebral disease diagnosis (Teather et al, 1985).

It's statistical data base consists of almost 1500 C.T. scan profiles collected over a five year period. Each profile includes a list of defined signs which describe any abnormality visible on the scan and a confirmed diagnosis. Sixty per cent of all cases also include an enhanced scan which is acquired by injecting the patient with organic iodine prior to the scan. This method sometimes improves the accuracy of diagnosis. Twenty five out of the twenty eight different forms of cerebral disease are represented on the database and data is still increasing. The system uses radiological information only.

The radiologist requiring advice from the system must describe the position and appearance of any visible discrete lesions (definition: any localised disturbance to the structure of the brain) and indicate the presence or absence of other signs (Du Boulay et al, 1987).

The system provides a shortlist of diseases and probabilities, based on the radiologist's description. In addition, the system is able to indicate signs which have provided evidence for the predicted diseases, with any signs conflicting with the diagnosis.

Advice is also available on the likely value of an enhanced scan where the patient is injected with iodine. The enhanced scan is not always of diagnostic value and there are side effects for the patient taking organic iodine. The system looks forward, using a statistical model, to investigate the possible effects of enhancement on the system's diagnostic advice. The system produces an indication of the chance of an enhancement leading to a change in diagnosis including a list of alternative diseases that may need to be considered. If an enhanced scan follows the advice, its description may be added to the information input and a revised diagnosis obtained (Teather et al, 1985).

This system will be used to provide radiologists with advice and, in addition, provide an educational tool for inexperienced radiologists. BRAINS is about to undergo an evaluation study at a hospital other than the site at which it was developed.

5.3.3. MYCIN

MYCIN selects antimicrobial therapy for patients with severe infections (Shortliffe, 1976). The knowledge used by the program was acquired from infectious disease specialists and was captured in the form of heuristics (rules of thumb) that relate to microbiological data and clinical signs and symptoms to possible pathogenic organisms.

The system is built around a set of medical concepts, referred to as clinical parameters, including the surgical history of the patient and the identity of infecting organisms. Production rules are built using relations between the clinical parameters and are of the form:

"IF premise THEN action".

The premise of the rule is formed by the conjunction of statements about clinical parameters e.g. "The age is greater than 16". The action portion of the rule states what conclusions can be drawn from the premise with an associated measure of certainty.

To perform a consultation, the rules must be combined together to form a line of reasoning. MYCIN uses a goal directed approach to integrate the knowledge (called backward chaining).

It starts at the top level goal (i.e. to prescribe the appropriate therapy) selecting the set of rules that make a conclusion about the goal in their action part. The premise of each rule is evaluated in order to find out whether that rule can be applied. The program identifies other rules that make a conclusion about a fact, if it is not available, but required to evaluate a premise.

The consultation program contains no knowledge of infectious diseases and can only manipulate the rules.

5.3.4. INTERNIST

INTERNIST (Myers et al, 1982) is a program to aid general internal diagnosis. Its database associates every possible diagnosis with a set of manifestations. A manifestation is a finding, symptom, sign, laboratory data or another diagnosis associated with the diagnosis. For every manifestation tested under a particular diagnosis, two numeric values are listed. The first is the evoking strength that if the manifestation is seen its cause is the diagnosis under which it is listed. The second numeric value is the frequency of a patient with the confirmed diagnosis exhibiting the manifestation (Oleson, 1977).

INTERNIST classifies all possible diagnoses into a disease hierarchy which allows a single general diagnosis to stand for all its possible specialisations if there is no discriminating evidence allowing a specific diagnosis. Confirmation of a diagnosis occurs when a diagnosis reaches a numeric threshold.

5.3.5. DIABETA - An expert system for the management of diabetes

St Thomas's Hospital, London are currently developing an expert system to aid the General Practitioner and hospital diabetic clinics in their care of adult diabetics and it is described fully in chapter 4.

It is proposed that the system will contain a simulation module on the action of diabetes and a knowledge base of diabetic management rules (Harvey, 1988).

The system is intended for diabetic information gathering and as a means of structuring consultations. In addition it will be used as a teaching aid for medical staff.

DIABETA is being developed on a 68000 based microcomputer running Unix. The ruleset is being written in Sigma-Prolog with the aid of an expert system shell APES. The database management package, Sculptor is written in C (Harvey & Carson, 1985).

5.4. Software tools for Expert System Development

5.4.1. There are a wide range of software tools available for expert system development starting at the most basic logic based programming languages to the most sophisticated software packages. Expert systems may be developed using a logic based programming language such as Prolog (Clocksin & Mellish, 1987) or it may be necessary to utilise a comprehensive expert system development package with a full back up service from its manufacturer (Chung & Kingston, 1988). Alternatively a less comprehensive package may be more appropriate.

Expert system development tools are offered by many companies and new products are increasingly available. These software packages are essentially "shells" that allow non artificial intelligence specialists to build expert systems for many applications (Goering, 1984). Each package provides an inference engine and a variety of programming and graphics tools for building a knowledge base.

The knowledge base is built by the user specifying a sequence of rules, giving examples of decisions or providing lists of items and their characteristics. Many packages will diagram a chain of reasoning or explain why the system has reached a given conclusion. Training and support is often provided for the users.

Some kits use rule based reasoning requiring a different type of input and offers different advantages from a kit using frame based representation. Rule based reasoning represents knowledge in the form of IF-THEN rules, while frame based representation classifies objects and their attributes in a semantic network (Chung & Kingston, 1988). Both kits are fully described below.

Very often the tools can only solve 10% of the application (Goering, 1984) and the rest must be solved using general purpose computer programming language. Some development kits were originally designed to solve a specific problem and it is therefore essential that the type of application is considered when considering purchasing a kit.

5.4.2. Logic Based Programming

The most basic software tools for expert system development are logic based programming languages, i.e. those based on predicate calculus, and can be used to build expert systems. Procedural languages such as Pascal describe how to compute a result, logic based languages specify what result is desired.

Many medical decision making and diagnostic systems have their programs written in specialised languages such as LISP (Winston & Horn, 1981) and PROLOG (Clocksin & Mellish, 1987). Both LISP and PROLOG specialise in facilities to handle rule evaluation and they are, in general, limited in the size of their fact and knowledge bases because they both operate on stored facts and rules with awkward recourse to file structures. Neither language has data collection, storage and retrieval applications.

Procedural languages such as Pascal, PL/1 and MUMPS have comprehensive facilities for interactive data collections, report generation and database manipulation but they lack tools to manipulate or apply knowledge bases of rules. A combination of both types of languages may be used in the design of a medical system (O'Kane, 1986).

Attempts to add rule manipulation facilities to procedural languages include a MUMPS interpreter written in C in which a logic programming interpreter similar to PROLOG is embedded (O'Kane, 1986).

The MUMPS interpreter attempts to consolidate features from two distinctly different types of language into a hybrid system in which the existing MUMPS global array facility can be used to store the facts and rules.

Such a system allows existing MUMPS applications to be upgraded to expert systems by adding rule structures to evaluate existing data and knowledge bases. Both logic programming and traditional data collection, storage, retrieval and report generating functions are available (O'Kane, 1986).

Smart Systems sells Duck, a logic based language that provides an inference engine with support tools (Goering,1984).

Duck can update its reasoning strategy. It can reason with assumptions or incomplete information by assigning default values for variables. If the assumption was false, Duck can update all related data on the knowledge base.

5.4.3. The Dual Approach

Packages combining a mix of reasoning and decision making strategies are most versatile when solving a variety of problems. KEE is such a tool, using both frame based representation and rule based reasoning to build its knowledge base. The inference engine uses both forward (starting with the facts and drawing a conclusion) and backward chaining (concludes a possible hypothesis and works backwards to verify the facts that will substantiate it).

KEE uses object orientated programming. An object is an entity representing a collection of information. Objects are organised into hierarchical "classes" and each object is associated with characteristics called "attributes". A new object can inherit attributes from another object which means the system can infer characteristics without user input.

Object orientated programming allows frame based representation saving redundant entries because attributes can be inherited. In addition, the number of rules a system needs to store is reduced. In a pure rule based system all relationships between objects have to be specified by rules. Many people find it easier to work with rules because they are simple and direct, and they best codify the procedural knowledge of a domain.

Xerox's Loops is a similar system to KEE but lacks the support KEE provides and this is reflected in its price. Similar kits are SRL + from the Carnegie Group and Knowledge Engineering System (KES) from Software Architecture and Engineering.

5.4.4. Exploration of Hypothetical Worlds

The Automated Reasoning Tool (ART) developed by Inference Corporation combines rule based, frame based and objected oriented approaches. In addition ART has a built in mechanism to process and represent a large number of possible alternatives simultaneously, and it is the first language that has the semantics for parallelism.

ART uses a blackboard mechanism to process "viewpoints" which are views the rules have of the knowledge. This allows ART to chart alternative courses of action called "hypothetical worlds", so ART can consider potentially conflicting alternatives or explore many aspects of one problem i.e. exploring WHAT IF rules as well as IF THEN.

ART can evaluate a situation that changes over time (time modelling). "Confidence values" are assigned giving a qualitative estimate of a viewpoint's accuracy and the best viewpoint is promoted as the desired solution. Viewpoints are processed simultaneously cutting the processing time substantially.

This development tool can find "patterns" in data and draw inference. In addition, forward and backward chaining can be combined in a single application. ART was used to build the Navy's console control system at NASA's Johnson Space Centre.

5.4.5. Multi Level Approach

Technowledge offer three different products, M1, a prototyping tool, T1, a tutorial package, and S1, a full scale expert system development kit.

M1 is a backward-chaining, rule based kit that can build a small expert system (about 200 rules) or a prototype and is built in Prolog. It features a multi window display, interactive debugging and automatic question generation.

A similar package is the T1 Personal Consultant which can create an expert system with up to 400 rules.

S1 is a backward-chaining, rule based system that includes frame based representation. Users primarily enter IF THEN rules and S1 can store frames that describe objects and their relationships. The manufacturers claim that S1 has fewer functions than KEE or ART but it is easier to use. S1 is designed for applications requiring "structured selection", that is problems with definable solutions. S1 would be appropriate for applications such as diagnosis but not for design. General Motors is currently using S1 to build a car diagnosis system.

5.4.6. Fuzzy Logic Approach

Infotym's Reveal is a Pascal type language with a set of development tools for building expert systems. It combines expert system development with a decision support modelling tool. Reveal is a rule based system best suited for applications with over 200 rules.

In addition to artificial intelligence applications, Reveal is a complete programming language that can be used for general purpose programming.

The language makes use of fuzzy logic which allows a degree of truth to be assigned to statements. A fuzzy set does not have a crisply defined membership but allows objects to have grades of membership or truth values between 0 and 1.

User defined linguistic variables such as 'large' or 'small' are allowed and are evaluated by truth values scaled numerically from 0 to 1. Answers to problems are in the form of numerical confidence factors and this "approximate reasoning" capability allows the evaluation of imprecise information. S1 allows numeric "certainty factors" whereas Reveal provides the linguistics for approximate reasoning.

5.4.7. Inducing Rules From Decisions

Some kits induce rules from examples of decisions rather than requiring the user to enter the rules. These kits can build decision trees and generate rules to solve specific problems from the examples of previous decisions.

The suppliers of these packages claim it is easier to give examples rather than dictate rules but competitors point out that many examples are required to cover even a limited application.

Radian Corp's Rulemaster package includes Rule Maker, an inductive generator of decision trees, and Radial, a Pascal type language for expressing and executing rules. The user can enter explicit rules and examples, and Radial can explain a line of reasoning. Radial uses fuzzy set theory to evaluate variables such as "high" or "low". It is written in C and allows an interface to Fortran, Pascal, Lisp or C.

Expert-Ease supplied by Jeffery Perrone and Associates induces rules from examples and provides facilities similar to Rule Maker. It does not have a language like Radial and cannot explain a line of reasoning but it is low cost, has an easy to use interface and high speed decision making capabilities making it a popular package.

5.4.8. Expert System Development Toolkit Review

There are many expert system development tools currently available. The table below illustrates a sample of toolkits varying in cost, ranging from the most expensive to the least expensive products available.

TABLE 1 A Sample of Expert System Development Toolkits

Product Name and Distributer	Machines	Cost	Facilities
ART Ferranti Computer Systems Developer : Inference Corporation	Symbolics 3600 SUN, VAX (VMS) TI Explorer	£17,500 to £26,500	Hybrid toolkit. Knowledge Representation - facts,frames,rules, viewpoints etc. Inference - forward, backward chaining, truth maintenance, hypothetical reasoning.
Crystal Intelligent Environments	PC/XT/AT with 256 KB	£1000	Knowledge Representation - production rules Inference - Forward, backward chaining. Uncertainty Interfaces to : dBase, Lotus 1-2-3, Symphony, Dos, ASCII, C, interactive video
Advisor-2 Expert Systems International	PC	£500	Forward Chaining. Interfaces to : Lotus 1-2-3 dBaseIII, GEM Graphics, C
Edinburgh Blackboard Shell AIAI Developer : Dept. of AI, University of Edinburgh	Any machine supporting Edinburgh Prolog, C-Prolog, Poplog Prolog or Arity Prolog	£100	Access to Prolog, user definable certainty factors, strategies for rule select - ion, built in facility for maintaining consistency of facts

5.5. Discussion

Expert system development tools including expert system shells have the advantage that non-artificial intelligence and non-expert system specialists can build an expert system in a short period of time without specialist training (Chung & Kingston, 1988).

However, the initial cost of such a package is very expensive and a large expensive machine is required to run the shell. Their main use is in building prototype expert systems for industrial applications. They are used for prototypes rather than the completed system because their rule bases tend to be rather limited.

Shells are not versatile, possibly only solving 10% of a user's problem (Goering, 1984), and may not provide all the user's requirements. Many facilities may have to be built at an extra cost to the user.

Logic based programming languages such as PROLOG have facilities to handle rule evaluation but are limited to the size of their fact and knowledge bases. In addition they do not provide data capture, storage and retrieval facilities.

It has already been suggested that a computer system may assist in the management of diabetic children (Chapter 4). Diabetes is a condition which presents a particularly difficult control task for its management. Systems designed to aid diabetic management that are currently available (Chapter 4) assume constraints which are very often unrealistic e.g. unchanging activity from day to day. Diabetic management is a particular problem for children because growth and unpredictable activity levels affect control.

A fine balance between insulin, carbohydrate and exercise, and the maintenance of low blood test results must be pursued by the parents of the diabetic child.

Considering the extent of the management methods required to manage any child on every possible insulin regime it is appropriate to realise a computer system is required utilising the methods in order to aid blood sugar control. In addition facilities for easy access and manipulation of the methods by the clinician are required.

The system must be inexpensive, fast, reliable, easy to use and easy to learn to use so that it will be available to a large number of diabetic children. It must be able to cope with every type of insulin regime a diabetic child is likely to follow so that it is versatile enough for use by any diabetic child on any type of regime.

The facilities should include fast, easy to use data capture and help facilities. Education should also be considered by incorporating back tracking when problem solving. This will enable full explanations of an action advice given.

The vast quantity of methods or techniques that may be required to solve the management problems of a diabetic child on any insulin regime indicate that a computer system is required. Expert systems development tools are too expensive and not versatile enough for this particular problem.

The system will require a programming language capable of capturing and handling numeric data easily. The language must allow a user interface to be produced which would be designed specifically for the naive user.

Therefore a purpose built system should be designed using an inexpensive personal computer for use in the diabetic's home. In addition the language used should be widely available and the system should be written in a form that is portable.

CHAPTER 6

System Introduction

6.1. Introduction

The last chapter concluded that a purpose built computer system is required to assist the problem of managing childhood diabetes. It is therefore appropriate to identify the type of computer advisor system required. In addition the "knowledge base" and knowledge acquisition must be considered together with the implementation restraints.

The diabetic application requires that the advisor system should be implemented on an inexpensive and easily available computer system. The diabetic-machine interface requires a fast easy to use data capture facility with clear representation of data and easy to understand messages.

Advice must be considered carefully as it is the most important part of the system. Coherent, reliable advice is essential and an explanation for the advice must be included.

Every diabetic is an individual and has an insulin regime that is suitable for their physical condition and lifestyle. As changes in condition and lifestyle take place, the necessary changes must take place within their insulin regime. The system should be able to recognise and cope with this concept.

The knowledge required to implement the system must be available in a form that may be understood by the clinician. Utilities to view and amend the knowledge are necessary so that diabetics receiving new products can utilise the system.

6.2. Aims of System

The role of the system, within traditional diabetic care, is to add to the effect of existing and future facilities of the N.H.S. and supporting organisations such as the B.D.A. It will provide a source of information 24 hours per day, continually informing the techniques of diabetic management and insulin adjustment. In addition, the system will provide further support for the diabetic child and their family and be of educational benefit.

The main aims of the system can be summarised as:

1. to provide day to day advice to the child/parent of diabetic child on the complex task of blood sugar control.

2. to provide facilities for capturing data for the clinician involved in the longer term monitoring of the diabetic child.

6.3. System Facilities

In order to aid in the blood sugar control of the diabetic child the computer advisor system will be used to collect and interpret the information at present recorded in the diabetic diary and then utilise the appropriate items of information to provide advice on blood sugar control.

Thus this section now considers the main facilities that will be available in the micro based system.

6.3.1. Data Collection

The data collected will be that usually recorded in a diabetic diary. The system should prompt the diabetic/parents for details by displaying a menu of all the items to be input. The system will alert the diabetic when the data input is incorrect. The menu acts as a prompt for information and allows the system to run with the minimum of key entry.

6.3.2. Manipulation of Data

The data collected from the diabetic/parents should be stored on files and presented on the screen in a similar form to the diabetic diary with which he/she will be familiar. The test results should be monitored for problems, for example, repeated high test results. The monitoring may take the form of moving averages.

Height and weight of the diabetic will be used to check against the upper and lower limits of normal height and weight. This information is contained in a file of maximum and minimum height and weight in relationship to age.

6.3.3. Improved Advice for Blood Sugar Control

It is not unusual for a diabetic when suffering high blood test results to wait until the next clinic visit before the insulin regime is adjusted to prevent the problem recurring. Unfortunately high blood glucose levels lead to the long term complications affecting, for example, the small blood vessels of the eyes. The system will continually monitor the blood test results and alert the diabetic when necessary. Advice on insulin adjustment can then be given immediately and the diabetic can act on the advice promptly.

By monitoring the blood test results and offering the appropriate advice the system may improve blood sugar control and perhaps help to avoid some of the long term complications of diabetes.

6.3.4. Clinical Report

The clinician scans the diabetic's diary at the clinic looking for problems with blood sugar control represented in the recorded blood and urine test results. The system must produce reports for the clinician in a form similar to the diabetic diary. In order to aid the clinician a summary report will be printed at the end of the diary report. This report will include the total and average test results for the morning and evening tests. In addition periods when the diabetic has high test results or when hypoglycaemia occurs are printed out again at the end of the report in order to highlight the problem

6.3.5. Education

The system aims to be of educational value in two ways. Firstly the help facility within the system will explain how to use the system and emphasise the need for regular blood and/or urine test results.

Secondly the advice module explains why particular advice is given including the actual advice. In addition when advice is given, the previous advice and reason, if related is displayed at the same time.

The system will continually reinforce the techniques of insulin adjustment each time insulin is changed.

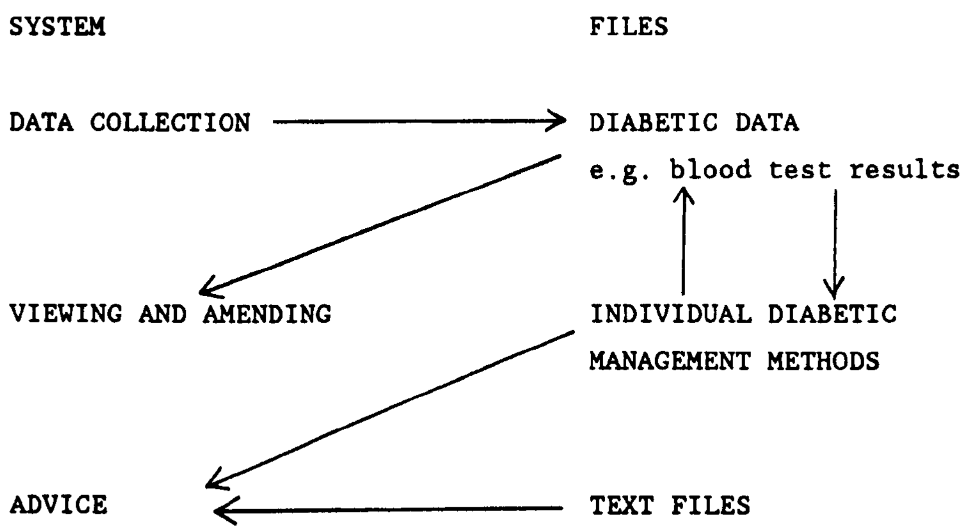
6.4. System Structure : An Overview

The major area of research seeks to establish a full set of management techniques for the care of childhood diabetes. Since each child follows an individual regime, each user will require management methods that are tailored to his/her particular status. Thus the main structure of the individualised system is now described.

Information utilised by the clinician in order to treat and advise his diabetic patients is held in the management methods file.

The system will broadly split into two main parts, the systems programs and the files, and may be implemented on an inexpensive dual floppy disk system.

FIGURE 7 INDIVIDUALISED SYSTEM



The system disk will contain the main modules of data collection, advice, viewing and amending. The files fall into three main categories data files, management method files and advice text files. Data files will contain all the personal data both daily and periodically that has been input by the diabetic.

The most important file is that of the full knowledge set containing methods for managing diabetic children on any insulin regime. The full set of management methods will be used during the system initialisation stage only when an individualised system, utilising a subset of the full set that is relevant to the user is established.

The advice text file contains all the advice text required for a particular diabetic regime. The appropriate text is accessed by a text code. All the files, including the method of compilation and contents are fully described in Chapter 7.

6.4.1. Data

The information stored in the data files will include all the information currently recorded by diabetic children or their parents in the diabetic diary. The information primarily concerns all the blood and urine test results, carbohydrate intake and the insulin regime. However additional notes are taken when the child suffers for example an episode of hypoglycaemia or illness such as a cold.

In addition a personal file will contain information such as date of birth and height and weight. Obviously it is necessary from the point of view of speed that the daily information files contain a minimum of data. The personal file contains information that changes periodically if at all.

The daily information is collected through the day and stored in a fixed format file. This information may be accessed and amended through the day.

6.4.2. User Utilities for the Clinician

It may be necessary for the clinician to view the management methods. In order to facilitate this a utility needs to be created to take the knowledge file and display it in a form with which he is familiar. The knowledge file contains the coded techniques for adjusting insulin doses and the utility converts the code into English sentences.

The clinician may amend the techniques if necessary and the management methods are appropriately updated by the system.

6.5. Implementation Considerations and Discussion

In order to develop the described system there are two major areas of work to be completed. Firstly the production of a system that is similar to the diabetic log book, collecting blood test results and other diabetic information. In addition the full set of management methods should be established in order to provide diabetic advice. The methods and algorithmic approach to diabetic management will be discussed in more detail in chapter 7.

The system may be used regularly every day and users may prefer to input information as it occurs or once a day. There should be no constraints on the number of times the machine may be used. In addition a system may be used for the sole use of one diabetic or may be shared with others. A clinician may find it useful to offer the system on loan, for a period of time, to his patients in turn.

The machine used to implement this system should be inexpensive and easily available. However a prototype system may be developed on a different machine with the emphasis on portability. In addition the language used to write the system must be inexpensive and widely available such as BASIC or PASCAL. However, care must be taken to ensure that the system is easily transferable to other hardware.

CHAPTER 7

Knowledge Engineering for the Diabetic Management System

7.1. Introduction

Expert systems are growing in popularity in business and industry and consequently literature and conferences on the development of expert systems is an expanding area (Chung & Kingston, 1988).

Systems development processes for expert systems are different to that of standard software systems development in that in expert systems development a larger proportion of the development time is involved in planning and in deciding what knowledge should be encoded into the system.

The bottleneck in the development of an expert system is extracting knowledge from the expert (Olson & Reuter, 1987) i.e. knowledge acquisition. If the knowledge base is incorrect or badly designed then the whole system may fail (Ruszowski, 1986).

There are two classes of methods for acquiring expert knowledge:

Direct methods ask the expert to report on knowledge he/she can directly articulate. These methods include interviews, questionnaires, simple observation, thinking out loud, protocols, interruption analysis, drawing closed curves, and inferential flow analysis.

Indirect methods involve the expert performing a variety of tasks e.g. to rate how similar two objects are. The resulting information can be utilized by the analyst who can make inferences about what the expert must have known in order to respond the way he/she did. The methods used include multi-dimensional scaling, hierarchical clustering, general weighted networks, ordered trees from recall and repertory grid analysis (Davies & Hakiel, 1988).

This research utilised the direct approach to knowledge acquisition as described in this chapter. Consequently a major part of the research work involved knowledge acquisition from the expert responsible for managing blood sugar control in diabetic children, that is, the clinician.

The clinician utilised an iterative cycle approach to the treatment of diabetes. This technique involves a

treat - observe the result - treat again if necessary

approach to insulin adjustment. This method has been used for many years and involves the clinician's experience and understanding of the individual patient.

This technique does not translate efficiently to production rules and because efficiency is a fundamental requirement of this system existing PC rule based shells were considered unsuitable (Golden et al,1986).

In addition further requirements could not be satisfied by such shells:-

a. Facilities are necessary to allow the user to input numeric data.
b. Clinical reports must be generated by the system.
c. The user interface design for a non computer specialist must be implemented using non-artificial intelligence terminology.

These facilities are not available in existing micro based expert systems shells, and the cost associated with purchasing and tailoring more advanced shells to give access to (again costly) expensive data base packages could be unrealistic.

Thus in addition to the knowledge base, it is necessary to design a purpose built shell to support both the advisor system and generation of clinical reports with a suitable interface for the non-computer specialist.

7.2. Methods for Knowledge Acquisition

Techniques of knowledge acquisition can be conveniently grouped under two major headings: Direct and Indirect. The decision as to which class of acquisition procedures to use will depend largely on whether an appropriate expert is available with the time, willingness and ability to articulate his/her expertise.

7.2.1. Direct Methods

Interviews are the most common method for eliciting knowledge from the expert. During conversation the expert reveals the objects he/she thinks about, how they are related or organised and the processes he/she goes through in making a judgement, solving a problem or forming a solution. Interviews have a distinct advantage in that they can elicit unforeseen information because they are free form and the expert can generate information in the order he/she wishes at the level of detail required. However interviews can be very time consuming.

Another commonly used method for acquiring expert knowledge is questionnaires. They have the advantage that they are a very efficient way of gathering information and the expert can fill out the questionnaire in a leisurely and relaxed atmosphere. Questionnaires can be particularly useful in discovering the objects of the domain, in uncovering relationships and perhaps in determining uncertainties if the expert attaches uncertainty to its conclusions. In order to pose the appropriate questions in the questionnaire it is necessary to use another direct method before imposing the questionnaire. Obviously if the relevant questions are not asked the necessary knowledge will not be acquired.

Often the best method to discover how an expert makes a judgement, diagnosis or design decision is to observe the expert working at a real problem. Notes may be taken at the time or the process videotaped for later analysis.

A similar method is protocol analysis. The expert is observed, while working at a problem and must 'think out loud' while performing the task. The advantage is that there is no time delay between the act of thinking and reporting it. However protocol analysis is not appropriate for all kinds of tasks.

Interruption analysis preserves the natural thought process of the problem solver and allows him/her to proceed until the observer can no longer understand the expert's thought processes. The observer then interrupts the expert and asks detailed questions about what the expert did. Although this process may be instructive for the observer there is little chance that the process can be continued following interruption.

7.2.2. Indirect Methods

All of the previous methods ask the expert directly what he/she knows relying on the availability of the information to both introspection and articulation. Sometimes experts perceive complex relationships or come to sound conclusions without knowing exactly how it happened.

In order to acquire the knowledge, indirect knowledge elicitation methods are required. The expert is not asked to express knowledge directly but given a variety of other tasks e.g. to rate how similar two objects are or to recall all the objects several times from several starting points. The analyst infers underlying structure among the objects rated or recalled from the results.

Such indirect methods of knowledge acquisition are more applicable to expertise about objects rather than procedural problems.

In the case of procedural or diagnostic problems knowledge may be acquired indirectly if previously recorded data is available. The data may be recorded in tables, for example, a list of symptoms or observations with an associated conclusion. This information then may be converted to a form that is suitable for analysis by means of a computer algorithm for rule induction.

Another indirect method of knowledge acquisition is by the expert talking about related problems rather than the actual problem in question. The knowledge engineer may then infer, from the information gathered, conclusions or facts about the relevant subject.

7.2.3. Discussion

In order to acquire information and knowledge from the diabetic clinician appropriate methods of knowledge acquisition must be utilised. Diabetic management may be described as a procedural type problem. Hard data on past diabetic management decisions and the corresponding results were not available so that automatic rule acquisition techniques could not be used.

The initial stage of knowledge acquisition involved the clinician being interviewed. During the interviews it was obvious that the clinician was able to convey much of his knowledge of diabetic management techniques through introspection and articulation. Thus direct methods of knowledge acquisition would seem appropriate for this application.

The following sections of this chapter describe the knowledge acquisition stages and how the knowledge is represented and utilised within the system.

7.3. Knowledge Sources

The techniques that are applied by the clinician in order to advise a diabetic on insulin adjustment must be identified and formally expressed in order to implement an advisor system. The main sources of information used in this application were the diabetic clinician and diabetic literature.

Literature on diabetes takes the form of books written for diabetics and their families (Kinmonth et al, 1982). In addition text books written for medical students explain the physiological basis of diabetes. Although the physiological condition of diabetes is well documented, the actual management techniques involving insulin adjustment are not documented in detail, particularly the problem of detecting an incorrect insulin adjustment.

It therefore is appropriate to capture the method used by the clinician and formulate it into a type that can be utilised by a computer system. The knowledge stored on files can then be applied to the user's requests for advice on insulin adjustment.

7.3.1. Knowledge Aquistion Methods

The knowledge for this system was acquired by a series of observations at the diabetic clinics and interviews with the clinician. The final knowledge set was written in a form the clinician understood and was confirmed by the clinician before coding and establishing the diabetic support system.

The knowledge acquisition stage followed a plan of carefully considered steps which are described below.

7.3.2. Preliminary Interview with the Clinician.

The preliminary stage of knowledge acquisition involved a general discussion with the clinician, concentrating on the problems of managing blood sugar control in the insulin dependent diabetic child. In addition the areas for further exploration were identified by posing the following questions:

a) how does the clinician identify problems
b) how does the clinician identify the cause
c) how does the clinician treat the cause
d) what is the form of treatment
e) how is it explained to the patient

7.3.3. Visits to the Diabetic Children's Clinic

To gather information about the treatment of diabetic children, it was necessary to attend the clinic for diabetic children, observing the actual consultations. The objective being to gain an overall impression of the clinical technique used in identifying problems of blood sugar control and its subsequent treatment.

The clinic observations took place at Leicester Royal Infirmary. The health visitor was in attendance and also participated in the consultations. The diabetic child was accompanied by their parents or a close relative. During the consultation the clinician examined the child's eyes and checked their rate of growth. In addition the diabetic diary was examined. It was noted that each child completed the diary with different levels of detail. A transcript of a clinic visit are in Appendix I. However to illustrate the clinician advising a child with persistent high test results the following dialogue is examined.

clinician : Your morning tests are persistently high. Have you thought of a way to prevent this?

child : Yes, but I'm not sure if it is right. I think I should use more insulin in the evening.

clinician : Good! That's correct, and do you know why?

parent : I had to let him work it out, I couldn't.

child : I'm not really sure, but it is the injection before the high tests.

clinician : Yes. Your high tests occur when the insulin taken the evening before is effective.

The child had been diagnosed a diabetic for 4 years and had managed to work out which insulin should be adjusted. However, he could not fully explain how he had arrived at the solution. His mother could not provide a solution to the adjustment problem and did not understand how the proposed solution was determined.

7.3.4. Formulation of 1st Stage Management Methods

The consultations were utilised in compiling charts illustrating the insulin adjustment required to solve different diabetic problems, such as persistent high blood glucose test results. It is important to note that insulin is only changed when the observed problem cannot be attributed to other factors such as unusual exercise.

TABLE 2 Insulin Effect Timetable

The table below indicates the time after injection when the type of insulin becomes effective and when the effect ends.

	TIME AFTER INJECTION	
INSULIN TYPE	EFFECT STARTS	EFFECT STOPS
Intermediate	4 HOURS	10 HOURS
Quick	1 HOUR	4 HOURS
Ready Mixed	1 HOUR	10 HOURS

The action chart in Appendix II-3 displays the daily timetable of the child and the appropriate insulin associated with a particular time span. The child follows an insulin regime of 2 injections per day. Each injection contains a quantity of both fast and intermediate acting insulin (see table above). The treatment times are established and dependent on the time at which the particular insulin is active in the blood. There is a time lapse between the time of injection and the time at which the insulin is effective.

Since every child has a different daily timetable of activities, meals, injections and follows a different insulin regime, an individual chart must be produced for each child.

The chart has obvious advantages in education and provides a simple guide to insulin adjustment for the individual diabetic.

7.3.5. Discussion with Clinician

The clinician confirmed the accuracy of the basic chart. The next stage involved discussing the follow up of blood test results after an insulin adjustment. Sometimes adjusting insulin levels, in order to solve a particular management problem, does not produce the required result in terms of the blood tests. For example, if insulin is increased in order to combat persistent high test results the actual result may be a series of hypoglycaemic episodes.

The reason for this occurring may be one of a number and each reason may have a different likelihood. At this stage, the set of actions and procedures for following up blood tests after an insulin adjustment and coping with incorrect insulin adjustments were emerging.

7.3.6. Formulation of 2nd Stage Management Methods

Once a diabetic has been advised to change his/her insulin in order to solve a particular diabetic problem, it is important to follow up the results of the action taken.

This stage of knowledge acquisition involved establishing the possible results of an insulin adjustment and if the result was unsatisfactory, deciding on the appropriate cause and consequent advice.

For each 1st stage insulin adjustment there are 3 possible outcomes:

1. the initial problem stops and blood sugar is well controlled.
2. the initial problem does not stop.
3. the initial problem stops but the opposite problem starts.

Obviously if the outcome is 1 then further follow up is not necessary. However if the initial problem continues then it is necessary to decide on a further course of action. In order to do this, the cause must be established for example, the insulin adjustment advice may have been incorrect or the advice may have been correct but the insulin adjustment was not enough.

Similarly, if the initial problem stops but the opposite starts, the possible cause may be the insulin adjustment advice, which may be incorrect or the insulin adjustment may have been too much.

There are several reasons why the outcome of an insulin adjustment might not be correct and all the possible causes and appropriate actions were identified at this stage.

7.3.7. Confirmation with Clinician

The two main stages of insulin adjustment were confirmed and the interaction of the two stages were discussed. This involved establishing the method required to identify the outcome of a 1st stage action.

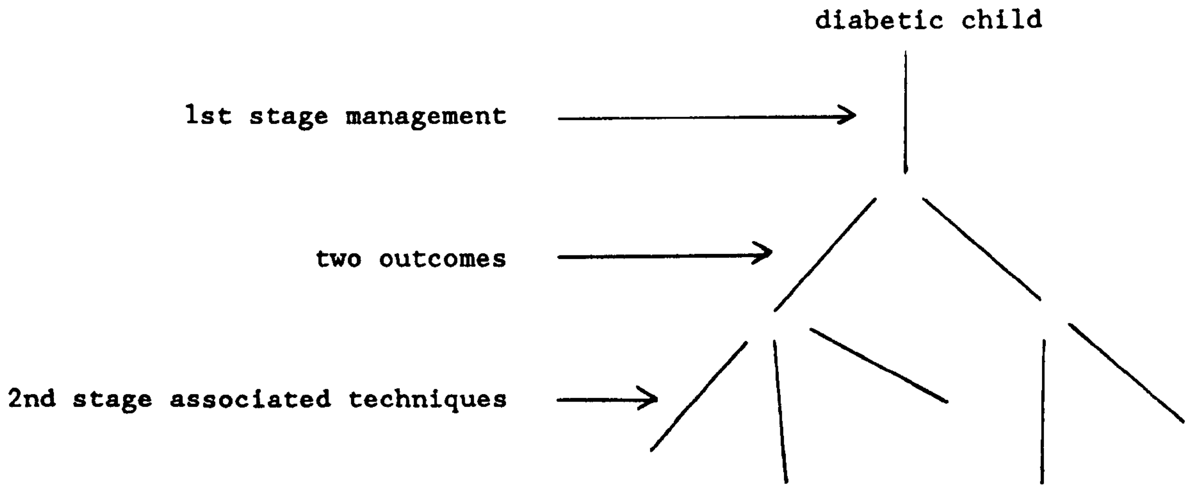
Once the diabetic has taken the 1st stage advice then the following blood and/or urine test results will be monitored. In addition the number of occurrences of hypoglycaemia will be monitored.

7.3.8. Expanding and Establishing the Knowledge Set

The basic techniques of insulin management were established but obviously not complete because each child follows a different lifestyle and insulin regime.

The methods for managing children following varying insulin regimes were established by expanding the basic techniques. The number of management techniques identified in order to set up this system was extensive. Each child may be following any one of a number of insulin regimes i.e. type, dose and brand of insulin. In addition each regime required a set of first stage management techniques and for every possible insulin change there are two outcomes that have several associated techniques (see Figure 8).

FIGURE 8 First and Second Stage Management



7.3.9 Planning and Coding the Knowledge

Once the full knowledge set had been established it was possible to plan and code an appropriate representation. The sheer size of the knowledge set indicated that it would be necessary to manipulate it in a way that would save system response time when the system was implemented. Obviously, each diabetic child follows only one insulin regime at a time and therefore only part of the knowledge set is appropriate for a particular child. Thus a method for extracting the appropriate subset of the full "knowledge base" would be necessary.

Coding the knowledge was initiated when the planning stage was complete. The main consideration was that knowledge should be accessed and read quickly and easily. The representation is further explained in section 7.4

7.3.10 Clinical Problem Solving

At the initial interview with the clinician several questions were identified. During the course of the knowledge acquisition stage the answers to the various questions were documented as follows:-

a) how does the clinician identify problems
b) how does the clinician identify the cause
c) how does the clinician treat the cause
d) what is the form of treatment
e) how is it explained to the patient

a) The patient may express his symptoms by the clinician questioning the child or his parents. The clinician also examines the log book looking for persistent high test results or hypos. This indicates that blood sugar control is poorly controlled perhaps at certain times of the day.

b) The cause of the problem may be quite clear in the log book or the diabetic may be questioned in order to identify the cause. The clinician will conclude the most likely cause by a process of elimination.

c) The treatment of the problem obviously depends on its cause. The cause may be ambiguous and the most likely is initially treated. The result of the treatment is then observed to establish whether the diagnosis was correct. Further treatment may be required at this stage particularly if the treatment has not stopped the symptoms.

d) The form of treatment covers a wide range from a quite small change in the diabetics regime, for example, changing the time that a meal or snack is eaten to a change in the quantity of insulin taken. There are other treatments such as a different insulin brand being prescribed but this can only be undertaken by the clinician.

e) The information may be conveyed to the patient or his parents in a way that the clinician considers appropriate. However a quantity of education is built into the explanation since the reason for the treatment is explained.

7.3.11. Conclusion

Knowledge acquisition involves establishing what constitutes a problem in diabetic management and identifying its cause. For every possible problem there are several associated possible causes that vary in likelihood. A problem such as high blood test results recurring at a particular time must initially be considered within the context of lifestyle and carbohydrate intake. If the cause cannot be identified within this context then it is necessary to consider adjusting the patient's insulin regime.

Once the appropriate advice has been established and conveyed to the patient the next step is to monitor the patient's blood tests and possible form of the problem recurring or another problem starting. The test results again need to be considered in order to establish the next course of action.

In order to implement this method on a system the total list of possible insulin regimes must be identified including the possible problems for each, the possible causes and treatments in order of the most likely. This information is documented in the following sections.

7.4 Diabetic Management Algorithm

In order to establish whether insulin is causing a particular diabetic problem a series of questions are presented to the diabetic user, for example :

Have you increased or decreased your carbohydrate intake ?
Have you missed a meal or snack ?
Did you exercise before the problem occurred ?

If the answer is no to each question it is concluded that insulin is the cause of the problem. At this stage it is necessary to identify which insulin should be adjusted. This function is performed by the 1st stage advice module which requires the time and type i.e. high blood tests or hypoglycaemia, of the problem to calculate which insulin should be adjusted.

7.4.1 1st Stage Management Techniques

The time at which the problem occurs is critical in deciding which insulin dose to change. The general management method involved in this job is to calculate which insulin is at its most effective when the problem occurred. If, for example, a diabetic child takes two injections per day, both containing a mix of fast and intermediate insulin and suffers mid morning hypoglycaemia the system is required to search the 1st stage management methods file for the appropriate time span within which the problem occurs.

TABLE 3 First Stage Management

Time From	Time To	Action on insulin
T1 + 1 hour	LT	A.M. Quick
LT	T2	A.M. Long
T2 + 1 hour	T2 + 4 hours	P.M. Quick
T2 + 4 hours	T1 + 1 hour	P.M. Long

where : T1 - Time of 1st injection

LT - Lunch time

T2 - Time of 2nd injection

Once the correct time span has been established then the corresponding appropriate action should be selected (see Table 3). The system stores the details of the particular insulin that should be adjusted (see Figure 9). The actual adjustment of insulin depends on the type of problem (see Table 4).

FIGURE 9 Diabetic Management Steps

PROBLEM STARTS

↓

ESTABLISH WHETHER INSULIN IS RESPONSIBLE

↓

ESTABLISH TIME AND TYPE OF PROBLEM

↓

IDENTIFY INSULIN TO BE ADJUSTED

↓

SELECT APPROPRIATE TEXT AND SEND TO USER

↓

IF THE USER ACTS ON THE ADVICE THEN STORE
ON BACKTRACK FILE FOR OPTIONAL FURTHER USE

↓

MONITOR RESULT OF ACTION TAKEN

TABLE 4 Diabetic Problem and Action Necessary

PROBLEM TYPE	ACTION
Hypoglycaemia	decrease insulin
High blood test results	increase insulin

The quantity of insulin to be adjusted is a constant 2 units because it is easily increased if the quantity is too little and the damage will not be too great if it was the incorrect solution. If there are further problems then 2nd stage advice techniques may be used.

Once the actual advice has been established it is sent to the user in a form that is easily understood. This is done by sending the necessary codes to the text file routine. The appropriate text is selected from the text file and displayed on the screen for the diabetic to read. If the diabetic decides to act on the advice displayed he/she will indicate this by pressing the appropriate key on the computer keyboard. The system then stores the advice that the diabetic will act on in a backtracking file. It may be used later if it is necessary to utilise the 2nd stage management methods.

The blood and/or urine test results and attacks of hypoglycaemia are monitored for the next few days in order to establish the outcome of the action. If there are no recurring problems then no further action is required. However if any associated problem occurs such as the original problem recurring or the opposite problem starting then the 2nd stage advice techniques must be used.

For each 1st stage action there is an associated set of 2nd stage management techniques. These are selected, at the 1st stage of insulin adjustment, from the full set of 2nd stage management techniques. This is further explained in section 7.5.

7.4.2 2nd Stage Management Techniques

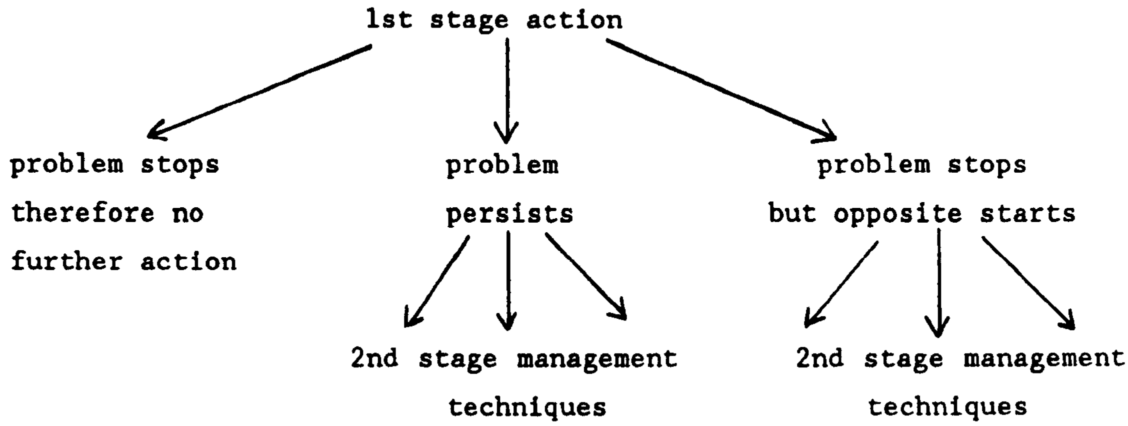
These techniques are used only if the 1st stage management techniques were used and were unsuccessful. Once it has been established that an associated problem has arisen due to a 1st stage action, the type of problem must be established. The problem may be one of 2 types:

(i) The original problem has stopped but the opposite has started

(ii) The original problem persists

For each 1st stage action there is a set of 2nd stage management techniques (see Figure 10). Each set consists of two groups of techniques, one for each possible outcome. Each group contains a list of further actions and are in the order of 'most likely' action to solve the problem.

FIGURE 10 First Stage Action and Second Stage Actions

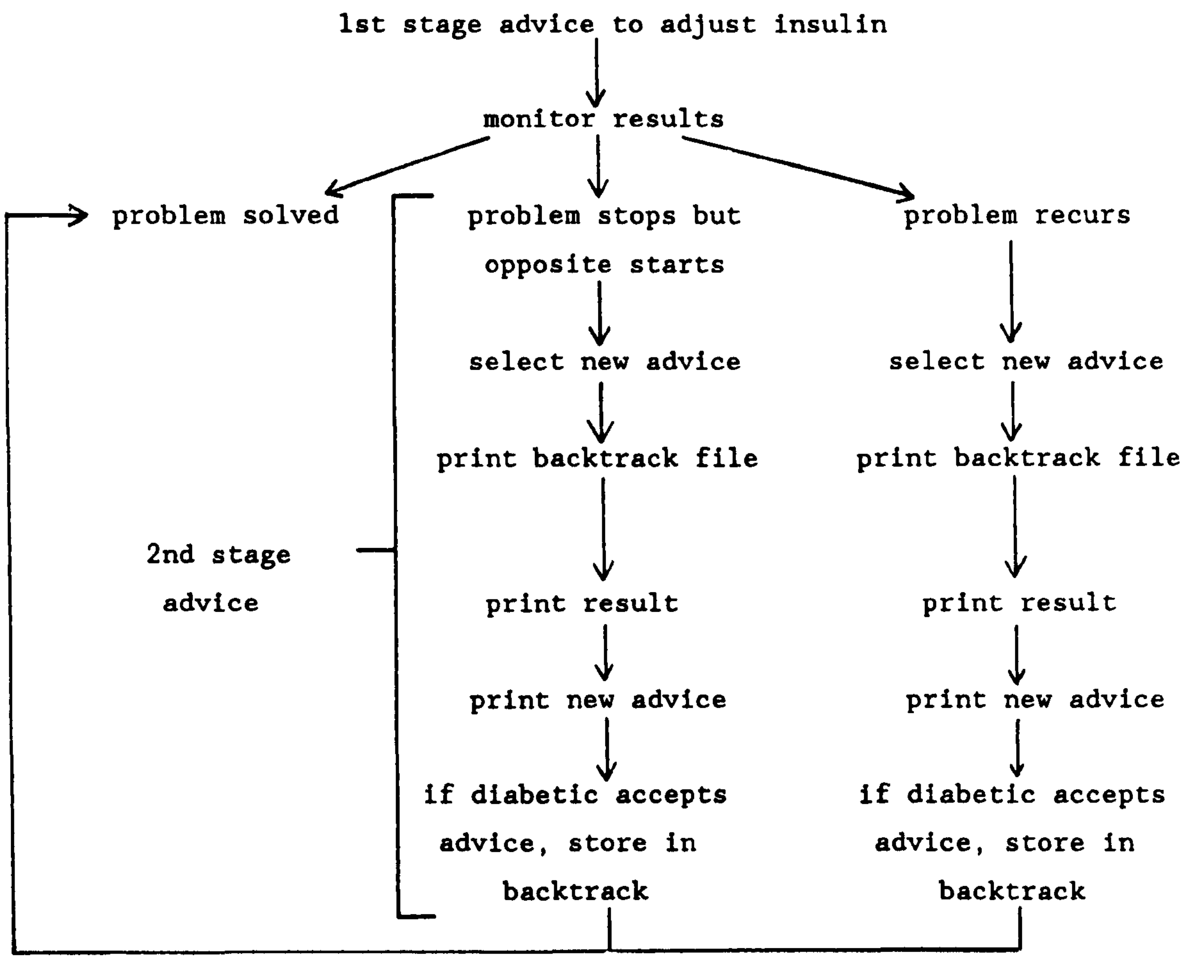


Once the outcome of a 1st stage action has been identified the next piece of advice is selected from the top of the list of the appropriate 2nd stage management techniques. The advice is stored in the file in numeric form and corresponds to an easy to understand statement stored in the text file. The information is displayed on the screen and if the diabetic decides to act on the advice it is also stored in the backtrack file. When the information is displayed on the screen, the previous actions stored in the backtrack file are also displayed. The diabetic can then follow the progress of his/her problem and the action taken.

Again, it is necessary to monitor the results of an action. If the result is not correct then the next 2nd stage action may be selected from the list and so on. However, at any stage of the advice module it may be necessary to advise the diabetic that a visit to the doctor may be appropriate, particularly if the blood/urine test results are persistently high or occurrences of hypoglycaemia are more frequent.

It is important to note that 2nd stage management techniques are only used when a diabetic problem has occurred and it is a direct result of a recent 1st stage action. It is concluded that 2nd stage management techniques are required when the problem occurs at a time close to the previous problem. The steps of diabetic problem solving are illustrated in Figure 11.

FIGURE 11 Diabetic Problem Solving Steps



Finally to illustrate the interaction of these management advice files, consider a child suffering symptoms of hypoglycaemia mid morning (see Figure 12).

FIGURE 12 Illustrative Diabetic Problem Solving

INITIAL SYMPTOM : HYPOGLYCAEMIA MID MORNING

TO ESTABLISH CAUSE :

Did he eat breakfast ? —n→ ADVICE: Eat breakfast

↓ y

Exercise prior to attacks ? —y→ ADVICE: Eat extra carbohydrate prior to exercise

↓ n

1st STAGE ADVICE : Conclude insulin needs to be adjusted therefore fast acting morning insulin to be decreased

↓

MONITOR RESULT

↓

RESULT: Problem recurs

↓

2nd STAGE ADVICE: Decrease Morning fast acting insulin again

↓

MONITOR RESULT

↓

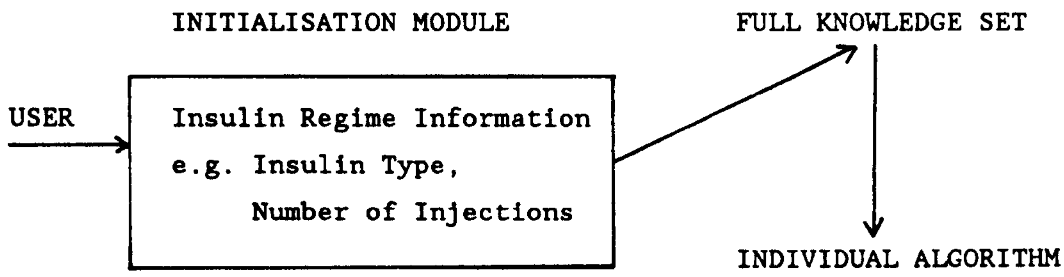
RESULT: Problem stops

7.5. Individualised System

Each user will require an individualised system appropriate to his/her insulin regime. The individualised system must be set up and initialised before the system is used. An initialisation module accepts the necessary information from the diabetic and uses it to select the appropriate knowledge from the full knowledge set.

The full knowledge set contains all the knowledge necessary to manage the blood sugar of a diabetic child on any insulin regime. The initialisation module establishes the insulin regime for the user and produces an algorithm appropriate to the management of a diabetic child on that regime. Obviously it is necessary to do this in order to save storage space and system operating time.

FIGURE 13 Initialisation of Individualised System



7.6. Conclusion

This chapter has described the knowledge set and the methods by which the knowledge was acquired. Interviews with the clinician resulted in the formulation of diabetic management methods and establishing a knowledge set. The main feature of this approach to management is its two stages.

It is important to note that the "knowledge base" is a set of files containing the diabetic management techniques of insulin adjustment. The techniques are sets of time boundaries associated with particular insulin regimes. The advice is based on these techniques and provides an algorithmic approach to diabetic management problem solving.

The knowledge set is too large to operate in its complete form and would result in a poor response time therefore file organisation and handling within the system must be carefully considered. Much of the system's design will require procedures for selecting the appropriate parts of the knowledge to produce a tailored system for the individual user.

In addition to producing an efficient system, the most important aspect of design is the interface. Many factors must be considered particularly the presentation of information and whether the system should be menu driven. Such considerations are discussed in the next chapter.

CHAPTER 8
Interfaces

8.1. Introduction

Since the advent of interactive computing in the early 1960's the man-machine dialogue has become of immense importance in the design of computer systems (Kidd & Cooper, 1983,Maguire, 1982, Muir, 1987, Wexelblat 1989).

Computer technology is utilised in all aspects of commerce and industry. In addition computers in education and the home are commonplace. The wide variation of applications has meant a wide range of experience and knowledge of computer users. The increase in non-specialist computer users using the computer as a tool to aid them carry out their tasks at work has led to criticism of poor interface dialogues.

It is widely recognised that it is no longer sufficient to provide powerful functionality and the way in which the interactive computer system interfaces to the user is considered critical (Richards et al, 1986).

The majority of systems are designed for more than one user and perform more than one task (Alvey, 1983). The design and implementation of the interface must consider both the physiological and psychological requirements of the user. However, a system may have many users who, in turn, have many different needs (Dekeyser & Willems, 1986). The user may vary from a novice user to an experienced user (Paxton & Turner, 1984). A novice or 'naive' user is someone who has little or no expertise in operating computers (Burgess & Swigger, 1986) but may soon become an experienced novice user. One of the newest fields of interface design is the concept of the adaptive interface and it is discussed in section 8.2.

The interface should assist the user in specifying his task requirements without getting in the way, allowing the user to concentrate on the task and not on the system (Richards et al, 1986). Interface design must support input by the user and text output e.g. error messages (Shneiderman, 1986, Shneiderman, 1987). There are several methods by which the system may be driven (Cruickshank, 1984) including menu selection and command language (Carroll & McKendree, 1987) .

This chapter considers the needs of the user operating the system described in this thesis. In addition the interface design possibilities are examined. The following section briefly describes the types of interface design available.

8.2. Types of Interface Design

There are several types of interface design (Smith, 1986). The most common types being the menu interface and command driven interface.Both menu selection and command driven systems have several similar and a number of contrasting features. In addition each have several advantages and disadvantages when considering the user requirements.

The menu selection interface allows the user to read a list of items and select the one required for the task to be performed. Command languages are distinguished from menu selection systems by the fact that the user must recall information and initiate the action by keying in the correct instruction.

Direct manipulation is an enhanced form of command language and allows visual interfaces in which the user operates on a representation of the objects within the system. A mouse replaces the keyboard entry. Direct manipulation is suitable for novices, easy to remember for intermittent users and with good design be rapid for frequent users. Currently, its applications lie in computer aided design and educational and non educational games. However, substantial computer power is required to support quality visual representation. GEM runs on a low cost PC but its visual representation is limited. Visual representation must match the user's model if the system is to be successful and therefore extensive research must be carried out before the design phase.

A relatively recent area of research is that of adaptive interfaces (Munro & Palaskas, 1987, Nemes, 1987). An adaptive system may make available tools relevant to a particular task and change their functionality to suit individual preference (Liang, 1987). Edmonds (1982) identifies adaptation in three categories, adaptation requested by user, prompted by system or automatic. The first two are considered forms of customising the system (Benyon et al, 1987) whereas the automatic adaptation means that the system interface adapts itself in response to the individual user and changes within the user.

The difficulty in successful design of an interface is the variety of tasks which a computer can perform and the variety of system users. In addition users change behaviour from problem solving through learning to routine cognitive skill as their experience with a system increases (Benyon et al, 1987). Thus there is a need for different interfaces for the same user and task at different stages. This leads to a difficulty as to when the system should alter to match the user's competence because users learn about a system at different rates. Each user will learn different things about the system at different levels within the system (Benyon et al, 1987).

The self adaptive (automatic) interface design allows the system to adapt to the anticipated changes automatically and enables the system to share the responsibility for adaptation (Liang, 1987). Liang explores an adaptive interface approach that controls automatic adaptation by keeping track of user profiles and adjusting system defaults.

Benyon et al (1988) describes an adaptive interface 'shell' which provides a framework within which different dialogues can be presented to different users. In order to do this the system needs to contain a detailed explicit representation of the user and of itself if it is to adapt appropriately. This will required substantial computing power.

Benyon et al (1988) concludes that adaptive interfaces will make a significant contribution to the development of human-computer interaction. However, much research is necessary in this area before self adaptive interfaces are widely implemented.

To conclude, the system described in this thesis must run on a low cost PC with limited hardware. The difficulties of design and implementation of direct manipulation and self adaptive interfaces on this type of machine suggest that a different approach may be more appropriate. The most popular types of interface implemented on this type of computer are menu and command driven. The following section describes both types of interface and compares their advantages and disadvantages paying particular attention to the interface requirements of the novice user.

8.3. Menu Selection Versus Command Driven Languages

Menu selection systems are appealing because they can, with careful design, eliminate user training (Sisson et al, 1986). In addition, with the options listed, the user need not memorise complete command sequences. The user when presented with a list of options written in a terminology familiar to the user, can easily make a selection, indicated by a minimum of key presses (Karat et al, 1986).

A further advantage of menu selection systems is the reduction in the possibility of keying errors and the easy to support error handling. In addition the menus prompt and guide the user, an obvious advantage for the novice user.

In order to optimise these advantages the designer must consider the design options available, for example, the menu system structure, phrasing of menu items, the sequence of menu items, selection mechanisms etc (Shneiderman, 1986, Shneiderman, 1987).

Type ahead may be allowed whereby the user types a string of letters or numbers at the main menu and without waiting to see the menus, choose an option in a further menu. This facility increases the speed of the system but an elaborate parser is required for the user input.

The disadvantages of menu selection systems are the danger of too many menus, frequent users may be hindered by menus and the menu display sometimes requires substantial screen space. However with good design and rapid display rate these disadvantages may be avoided.

Menu selection is unsuitable if data entry is required but this can be overcome with form fill in. Users must understand the field labels, know the appropriate values and data entry method and be able to respond to error messages. Some training may be necessary since knowledge of the keyboard, the labels and permissible fields is required.

However, with careful design, limited data entry requirements and extensive help facilities training is not necessary.

Command languages support user initiative. The users learn the syntax and can key in extensive commands rapidly. This type of system avoids the user having to read distracting prompts. In addition command language is convenient for creating user defined macros.

The main disadvantage of command languages is the high error rate and training is often necessary to use the system. Error messages are difficult to provide because of the diversity of command possibilities. Operating systems such as MSDOS are command driven.

Considering the novice user, command language is unsuitable because training is necessary and the error rate is high. It is an appropriate language for the knowledgeable frequent user.

The system considered in this thesis requires an easy to use interface designed for a home based diabetic management system. The command language interface is obviously unsuitable and therefore no longer considered.

This system will require the user to choose from a list of options and enter limited quantities and types of data. Therefore the design considerations of menu selection and form fill-in, including design guidelines are now examined in detail.

8.4. Types of Menu Selection Systems

There are several types of menu selection systems. The simplest is the single menu which provides a list of options on one screen and allows one choice. Binary menus offer the user two choices for example Y or N, true/false. Multiple item menus present the user with more than 2 items to choose from. The items may be presented horizontally or vertically and the user may make a selection in a number of ways e.g. menu bar, menu code etc.

Occasionally, an application may require a list of menu items that is larger than the screen size will permit. In this case the menu will extend over a screen. The user will be presented with a list of common facilities on the first menu and an option is provided to select the rest of the menu kept on a second screen. The menu may extend for several screens and a page scroll facility may be required.

Another type of menu is the pull-down/pop-up menu. The user makes a selection on a horizontal menu when the pull-down/pop-up menu appears. The horizontal menu remains on the screen and forms the heading of the pull down/pop up menu. Professional Cobol and Turbo Pascal 4 are examples of this type of menu. Menus need not disappear once the user has made a choice, the menu may remain on the screen permanently throughout the time the user operates the system. In addition, some systems allow the user to make multiple selections from the choices available.

Sometimes a series of interdependent menus is necessary to guide the user through a series of choices. The same sequence of menus appear regardless of the option selected by the user and may appear on the same screen. Linear sequences guide the user through complex decision processes by presenting one decision at a time.

If a collection of items for choice becomes large a tree structured menu approach may be appropriate. This is done by partitioning the items into groups. Classification and indexing is a complex task and a perfect solution is not always reached. Although there are design problems tree structured menus allow large collections of data to be available to the novice or intermittent user.

The terminology used in the tree structured menus should be specific rather than general (e.g. main menu). In addition the number of levels of a menu tree and number of items per level should be carefully chosen. Kiger (1984) and Van Hoe (1990) showed that the deep, narrow tree produced the slowest speed and most errors whereas the shallow, wider menu was best for speed and accuracy. Sisson et al (1986) concluded that operators are capable of handling information faster than some communication links and as technology allows faster transmission, the menu structures should become broader to allow the operator to function in a more productive manner.

A useful feature of a tree structured menu is a form of index, indicating to the user his position in the tree. Occasionally it is necessary to allow the user to access an option from more than one menu. However, the user must be provided with a 'level' or distance from the main menu in order to avoid user disorientation.

8.5. Design Considerations for Menu Systems.

8.5.1. Introduction

Good design of the user interface is essential for a successful system performance. The development of user interface design tools has produced a compilation of design guidelines (Mosier and Smith, 1986). The following section examines the design considerations for menu systems and the associated guidelines.

8.5.2. Sequence of Menu Items

The sequence of the menu items is important. If the items to be presented in the menu share a natural sequence e.g. dates, then the menu sequence is obvious. Often the items have no natural sequence and the possibilities the designer may choose are:

1. alphabetic sequence of items
2. grouping of related items
3. most frequently used items first
4. most important items first

8.5.3. Speed of Menus

Frequent users, including the novice may become irritated with making several menu selections to access the information required. Speeds may be increased by reducing the number of items in a menu. However it may be necessary to employ a different method to increase speed.

The type ahead for known menu choices methods allow the user to type a string of letters or numbers at the main menu and, without waiting to see the menus, choose the option in a further menu. The advantage with this method is that it allows an easy move for the novice from menus to a command language system. However, an elaborate parser for the user input is required.

Another approach to increase the speed of the system is to use numbered menus and assign names to each menu frame. The user may follow the menus or if they are frequent users and know the name of their destination they may enter the name and go there directly. This method is useful if the number of destinations the user needs to remember is small.

Finally menu macros allow the user to tailor the system to his own limited needs. The user when traversing a path regularly may record the path as a menu macro. The user invokes the menu macro facility, traverses the path and assigns a name. Then, in order to reach the destination the user invokes the assigned name.

8.5.4. Menu Presentation

The main considerations for menu presentation are firstly the title of the menu, secondly the phrasing of the items in the menu and lastly the layout and design of the menu.

For the single menu a simple descriptive title identifying the situation is required. The letters of a linear sequence of menus should represent the stages in the linear sequence. In addition, grammatical style should be consistent and brief noun phrases should be utilised where necessary. Titles for the structured menus should include a title for the root of the tree indicating to the user the start of the session. The exact words in the high level menu items should be used as the title for the next lower level menu.

Although menu choices may be written using English words or phrases it may not be comprehensible to every user. In order to reduce confusion the following guidelines should be adhered to:

1. Use familiar and consistent terminology.
2. Ensure items are distinct from one another.
3. Use consistent and concise phrasing.
4. Left justify the keyword because users scan the menu items left to right. If the first word indicates an irrelevant item, the next item may be scanned.

Lastly the constraints of screen size, character set etc. limit the graphic layout and design of the menus. The following menu components should be consistent throughout the system:

1. Titles should be centred or left justified.
2. Items should be left justified with item number or letter preceding. Blank lines may separate meaningful groups of items.
3. Instructions should be identical for each menu.
4. Error messages should appear in a consistent position.
5. The position of a tree structured menu should appear in a consistent position.

8.5.5 Methods of Selection

There are three methods of selection, firstly items may be numbered, secondly items may be lettered and finally the user may move the cursor to the item of his choice.

Numbered items have the advantage that the non-typist novice may find the key to make the selection easily. If the menu items have a numeric sequence then it is an obvious choice.

The disadvantage of this method is that when the number of items is greater than 9, two keystrokes are required to make a selection. Items such as help that appear on every menu in the system have different numbers on each menu. In addition numbers may indicate an unintentional order of preference to the user.

Lettered items may be sequential similar to the numbered items but allowing 26 choices before two keystrokes are necessary. Alternatively, items may be mnemonically lettered and are easy to remember because the letter is the first letter of the item. Mnemonic lettering allows meaningful type ahead selections if necessary.

The disadvantages with mnemonic lettering is that there may be two or more options with the same first letter and two or more keystrokes may be required to distinguish between the two.

Lastly, another approach is to allow the user to move the cursor to the option of his choice by arrow keys, mouse etc. This type of selection is appealing to the novice user even if more keystrokes are required to make selection. The menu item is highlighted on the screen and in the user's mind but this method cannot allow type ahead facilities.

Studies of menu selection devices, touch screen, mouse, keyboard were conducted to test user performance and attitudes to each technique. User preference for the touch screen and keyboard depended on the type of task being performed, while the mouse was always the least preferred (Karat et al, 1986).

8.6. Form Fill-In

Menu selection is appropriate when the user has to choose an item from a list. However, when data entry is required a form fill-in approach is more appropriate.

The screen has a suitable layout similar to a form for the user to enter data. The user may move around the screen with tab keys or the cursor may move from one field to another automatically.

The following guidelines should be adhered to when designing this facility:

1. meaningful title
2. comprehensive instructions
3. logical grouping or sequencing of fields
4. visually appealing screen layout
5. familiar field labels
6. consistent terminology and abbreviations
7. visible space and boundaries for data entry fields
8. convenient cursor movement
9. error correction for individual characters and fields
10. error messages for unacceptable values
11. optional fields should be marked
12. explanatory messages for fields
13. completion signal

8.7. Discussion

There are some common design considerations for both experienced and novice users. However, the novice user requires a system that is easy to use and easy to learn to use (Spavold, 1990). A menu driven interface is the most appropriate type of system for the novice user. One of the main advantages being that the list of options are displayed on the screen for the user to select. This means that the user does not need to remember the options available and the menu acts as a prompt for the user.

The novice can become an experienced novice very quickly and the interface design must cater for this fact. Options that will be requested regularly by the user must facilitate speedy access with a minimum of keystrokes.

Provided the data entry to be input by the novice user is limited and carefully designed, form fill-in is appropriate. In addition good instruction and help facilities will be required to support the novice user.

8.8. Conclusion

The user that will operate the system described in this thesis will be the diabetic child or the parents of a diabetic child. Computer systems are taught widely in schools so the child will most likely have some previous experience of computers. Home computers are very popular and some members of the family may have had some limited experience with a computer system. The family will obviously be keen to use the system and employ an extra aid in the management of their diabetic child otherwise they would not have elected to use such a system.

To conclude, the user is most likely to be an enthusiastic novice. Providing the system is used properly, that is, blood/urine test results are entered regularly, the user is likely to become an experienced novice very quickly.

The following chapter describes the dialogue designed for this system and justifies the choice of interface facilities.

CHAPTER 9

System Description

9.1. Introduction

The chief aim of the research described in this thesis is to identify the techniques of diabetic management and implement them within a personal diabetic management system. The system has been designed for the insulin dependent child and it is essential that the system adapts to changes in insulin and advances in medicine. A clinician's system has been produced to adapt the management techniques and supporting text files as the treatment of diabetes advances.

The diabetic system provides three main facilities: extensive data capture of diabetic information, a robust user friendly interface and, most importantly, accurate and easy to understand advice.

This chapter describes in detail the facilities of the diabetic system. The modules and file structures which support the system are described in Chapter 10.

9.2. System Outline

The diabetic system aims to aid the diabetic improve his blood glucose control by capturing diabetic data e.g. blood and urine test results and advising on problems such as persistent high test results. The system has extensive data capture facilities, a general information section and full help procedures. In addition an interface has been designed for the novice user who may become an experienced novice. The most important part of the system is the advice section which provided an activity chart, illustrating the time of injections, summaries of results indicating blood sugar control and specific advice on particular problems.

The clinician's systems primary function is to allow the management techniques and associated text to be amended. In addition a print option is available to provide a hard copy of the management techniques and text. Access is also given to appropriate facilities of the diabetic system i.e. general information, interface and advice facilities (see Figure 14). In addition the clinician's system can produce listings of the diabetic data in a diary format. The clinician's system is described fully in Chapter 11.

FIGURE 14 Facilities of Diabetic's and Clinician's Systems.

Diabetic system	Data Input	
	Data Display	
	General Information	
	Help	
	Interface	- menus
		- screen handling
		- error handling
	Advice	- activity chart
		- advice
		- result summary
Clinician's system	Change	- amend insulin file
	Management	- amend text codes
	Methods	- amend text files
	Print data diary	

9.3. Diabetic Interface

The diabetic system's interface is menu driven and its structure is outlined in Section 9.3.9. A menu driven interface provides an easy to use and easy to learn to use system by displaying a list of options and instructions on selection.

The diabetic data that is normally recorded in a diabetic diary is input via "form fill-in".

Pages of text are used for two parts of the system, the help facility and general information. In addition single pages of text are used to introduce several facilities.

Finally, error messages are used to indicate when the user has pressed an incorrect key or input invalid data.

9.3.1. The User

The system has been designed for the diabetic child who presents a particular problem for diabetic management because of their dynamic physiological condition and lifestyle. The design considers the user to have no previous knowledge of computer systems. However the user will probably become experienced over time and therefore the system has been designed in order that access to options used regularly will be fast and convenient.

The main aim of the system is to advise the diabetic on his/her condition by offering personal advice about the insulin dose. The methods for adjusting insulin dose are similar to scientific problem solving but it takes time to learn these methods. Therefore the system offers advice and, in addition, gives an explanation in order that over time the user may understand the methods.

To conclude, the user may be the diabetic child or the parents of a diabetic child. The user will more than likely be keen to learn about diabetes and the management methods required to promote good blood glucose control. In addition the system offers a comprehensive data capture facility and will be of use when the user becomes competent at insulin adjustment.

9.3.2. Introductory Screens

New users may require explanatory information concerning the concepts underlying the system. A number of introductory screens are therefore provided within the system. An initial screen introduces the system to the user. It briefly explains the aim of the system indicating the position of the keys on the keyboard and introduces the help facility. One of the most important points made on this initial screen is to remind the user that if he/she is in doubt or worried about his/her condition he/she should contact the health visitor or doctor.

The other introductory screen appears at the start of each option in the Specific Advice menu and each time the user is reminded to contact the health visitor or doctor if necessary.

The action chart gives the user an overall view of the changes to be made in insulin dose when a particular problem occurs. A brief description of the chart appears before the chart to explain its purpose.

The Results Summary option has a brief introduction before the summary is displayed. It explains the results and the target set by the doctor. It is important to note that no comments on blood test results etc. are made by the system.

The last introductory screen is displayed prior to the Problem Advice section. The main purpose of this screen is to warn the user that the advice given is personal advice based on the information stored. Therefore the advice is not appropriate for any other diabetic (unless of course the whole system is initialised).

These screens may be irritating for the experienced novice and they may be 'switched off' using the utilities.

9.3.3. The Menus

The system is menu driven and the menu is displayed to the left of the screen. Brief instruction on the method of selection is situated to the right of the menu. In order to make a selection the user moves the highlight bar over the appropriate option and presses return to confirm a selection. Each item on the list is the heading of the actual option. For example, option 3 of the main menu is Input Other Data. Selection of this option gives a further menu headed Input Other Data.

One of the main design considerations of the menus has been to provide fast and easy access to the options. There are a number of options within the whole system and the options used most are situated at the top of the menu. The highlight bar is in the top position to start any menu to cut down the number of keystrokes.

There are only two levels of menus (Figure 15). The main menu and four menus leading from the main menu. The menu system is wide and shallow rather than deep and narrow to avoid user errors.

FIGURE 15 Diabetic System Menu Structure

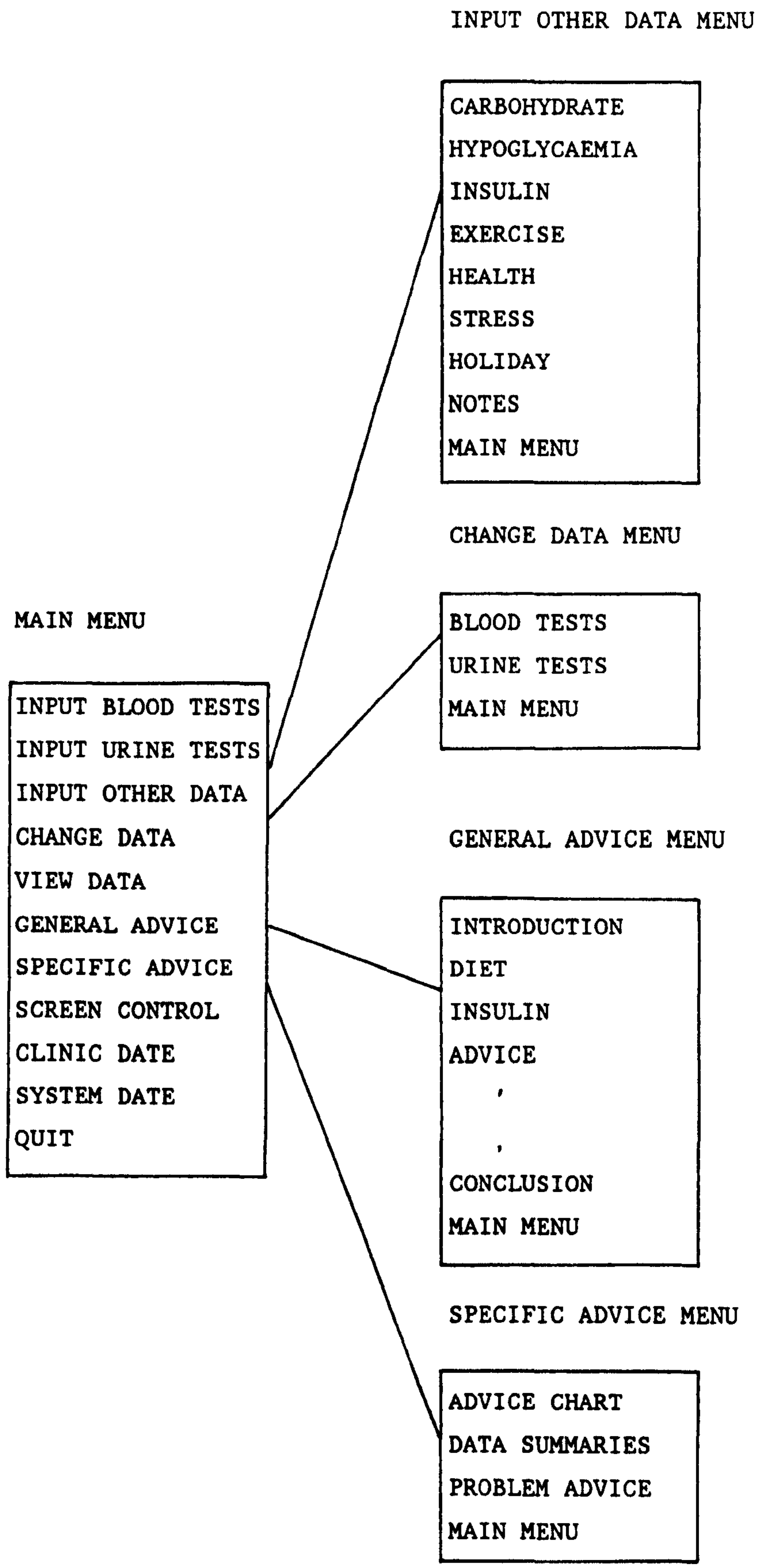
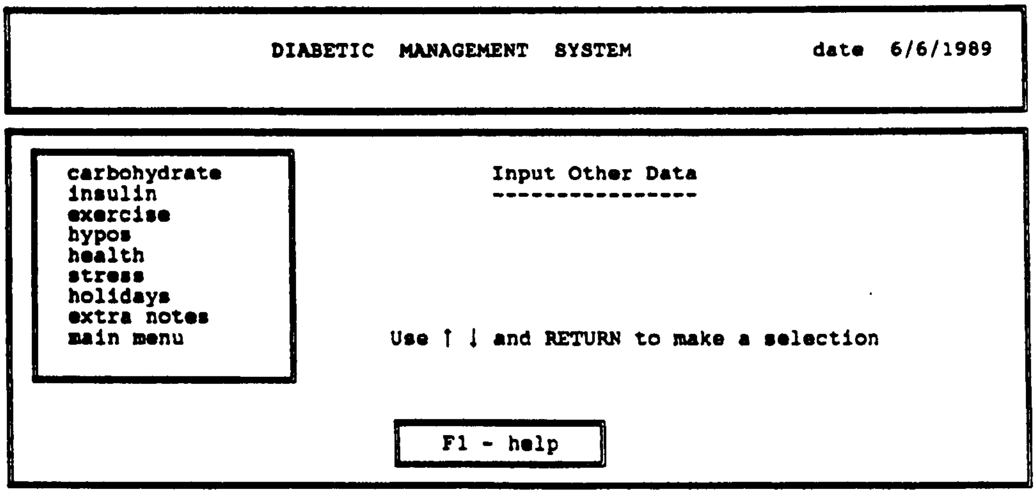


FIGURE 16 Menu Format

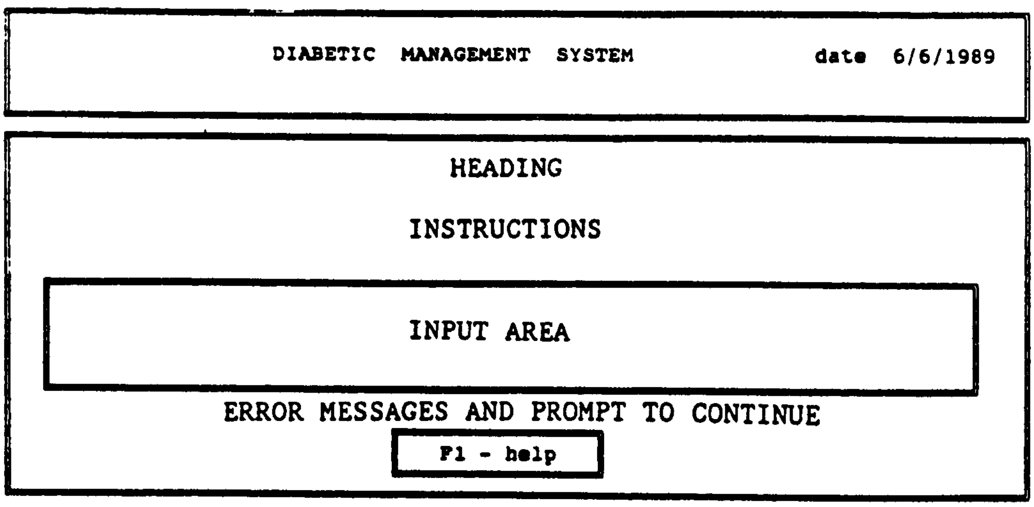
The menus appear on the screen in a consistent format as below.



9.3.4. Data Capture

The data input by the diabetic is the information normally recorded in a diabetic diary. All the information is entered via form fill-in and the format of the screen remains constant throughout this section (see Figure 17).

FIGURE 17 Screen Layout



9.3.4.1. Form Fill-In

The quantity of information that can be stored by the system is extensive but the type of data to be input is repetitive.

The information to be keyed in by the user is illustrated in Table 5.

It is assumed that the user has no previous experience of computer systems and typing and simple form fill-in are appropriate for collecting the above information. Simple instructions are provided so that the user knows the format of the data to be input. Figure 18 illustrates a typical screen within the system.

FIGURE 18 Example Screen

```
DIABETIC  MANAGEMENT  SYSTEM            date  31/5/1989

                  Input Health
                  ------------
Select From the list below, the illness (by pressing Y(yes) and N(No)).
You may press Y more than once.
Further information and notes may be entered in 'Extra Notes'.

        cold/sore throat/tonsilitis          [ ]
        temperature/flu                      [ ]
        tummy upset                          [ ]
        childhood illness e.g.mumps,measles  [ ]

                  F1 - help
```

TABLE 5 List of Data Input

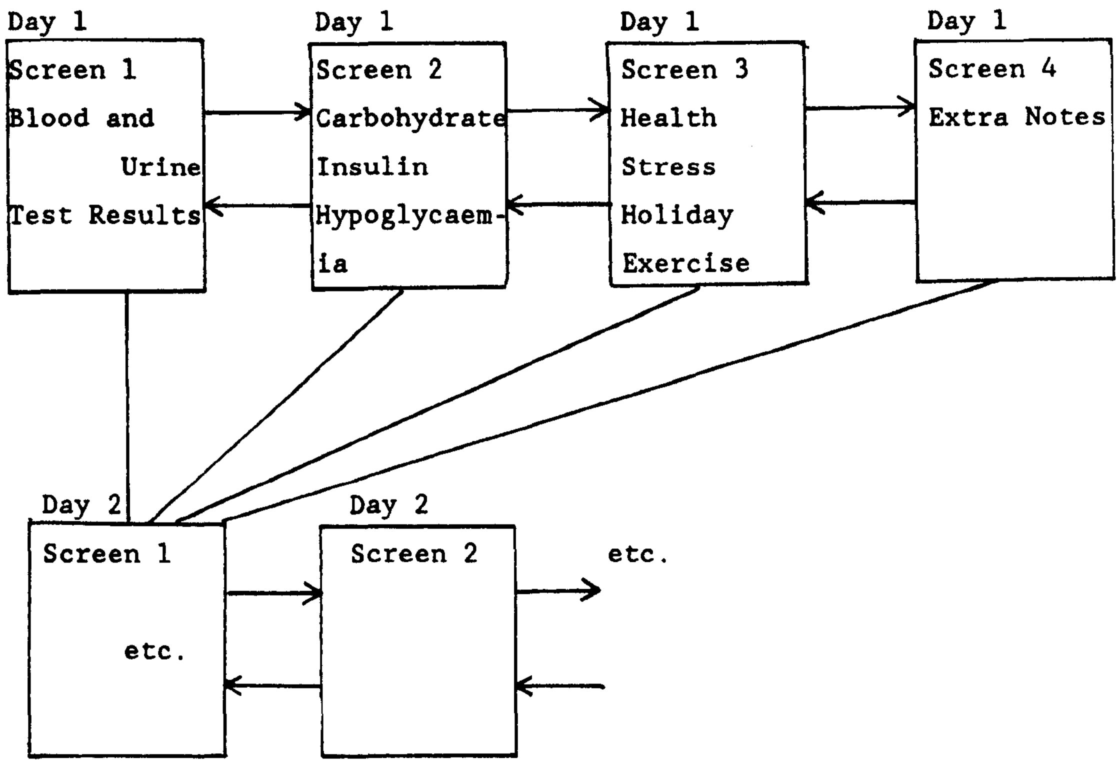
The user input required is simple and is listed below. In addition, the format for data input is consistent throughout the system.

blood test results	- time test taken and result of test
urine tests results	- result of tests against appropriate time
carbohydrate allowance	- carbohydrate in grams for each meal or snack
insulin	- the type, quantity and time of insulin
hypoglycaemia	- time of attacks
exercise	- time of start, time of finish, type of exercise
health	- Y or N against a list of symptoms
stress	- Y or N against a list of symptoms
holiday	- Y or N
notes	- free format for users own notes

9.3.5. View Data

There is a substantial amount of data stored within the system. In order to present the information to the diabetic and allow instructions to be displayed on the screen, one days data is spread over four screens. Figure 19 illustrates the content of each of the view data screens.

FIGURE 19 View Data Outline



9.3.6. Error Messages

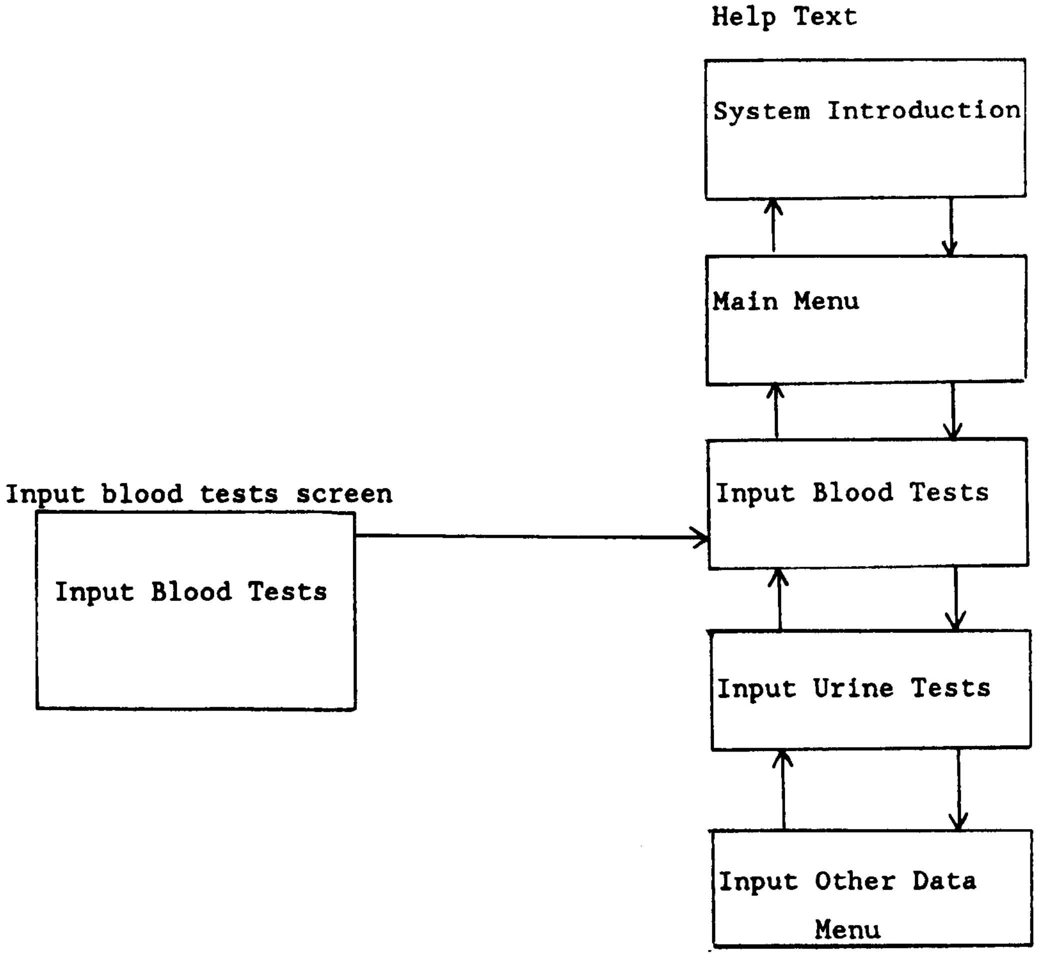
Error messages are displayed when the user presses an incorrect key or enters invalid data. The error message always appears in the same position, just above the help prompt, and is always highlighted. For example if the user presses 32 for a day number, when inputting the date, the message displayed will be :

invalid date - please try again

The error remains on display and the cursor moves to the initial position ready for the user to try again.

9.3.7. Help Facility

FIGURE 20 Outline of Help Structure

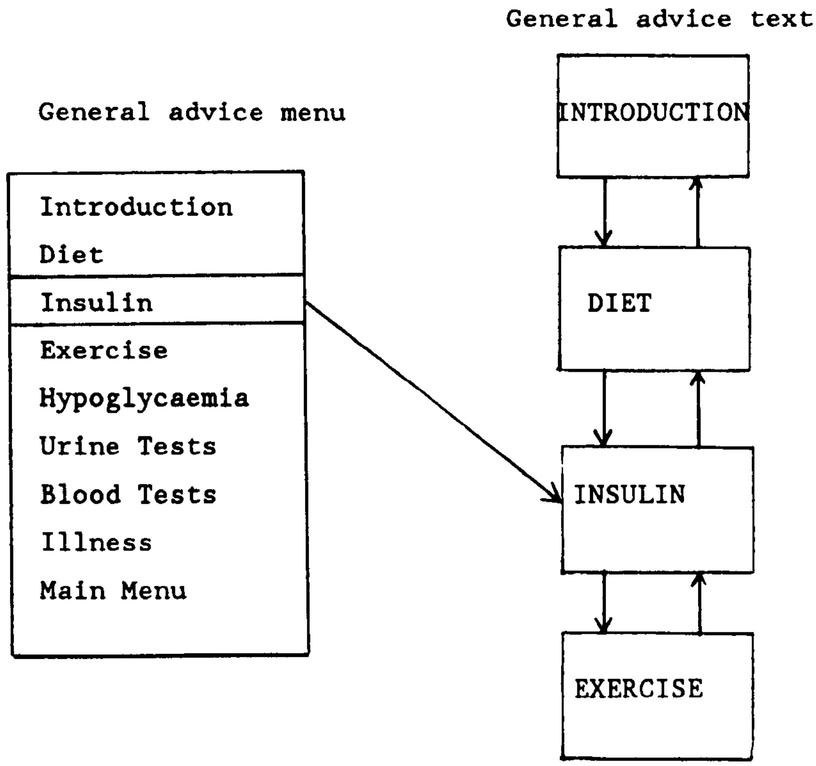


Help may be requested at any stage of the system's use and paged through to the end of the appropriate section (see Figure 20). When the user has finished reading help and pressed escape, the system returns to the point where help was requested.

9.3.8. General Advice

This option gives basic information about diabetes. It does not aim to replace a diabetic handbook but holds some of the most important points about diabetic management. The initial pages of text describe the condition of diabetes, leading to information on diet, insulin etc. and concluding with the importance of good diabetic management. In addition, the times when the diabetic should contact the doctor are included. General advice may be accessed from the introduction and the user may page forward as if reading a book or he/she may select the appropriate section he/she wishes to read via the general advice menu (see Figure 21)

FIGURE 21 General Advice Facility



9.3.9. Specific Advice

Specific advice differs from general advice in that it provides the user with advice on specific diabetic management problems i.e. high test results or hypoglycaemia using the users recorded blood and urine test results.

There are three approaches to the advice facility. The action chart provides the diabetic with an overall picture of his injection times and what action should be taken when hypoglycaemia or high test results occur.

The test summary facility displays the blood test result totals and percentages giving the diabetic an indication of blood glucose control.

Finally problem advice is given to the diabetic when he suffers hypos or high test results at particular times and his/her insulin dose needs to be adjusted.

9.3.9.1. Action Chart

A personalised action chart illustrates the general guidelines for insulin adjustment (see Figure 22)

FIGURE 22 Action Chart

Time	Meals	Injection Time	Problem Type: Hypos	Problem Type: High Tests
11.00 p.m.				
06.00 a.m.			Decrease	Increase
07.00	Breakfast	T1	p.m. long	p.m. long
08.00				
09.00				
10.00	Snack		Decrease	Increase
11.00			a.m. quick	a.m. quick
12.00 p.m.				
01.00	Lunch			
02.00				
03.00	Snack			
04.00			Decrease	Increase
05.00			a.m. long	a.m. long
06.00	Tea			
07.00		T2		
08.00	Supper			
09.00			Decrease	Increase
10.00			p.m. long	p.m. long
11.00 p.m.				

T1 - time of morning injection

T2 - time of evening injection

9.3.9.2. Blood and Urine Tests and Hypoglycaemia Summaries

A summary report of test results, occurrences of hypoglycaemia and test result targets may be accessed giving an indication of blood sugar control.

The summary of blood and urine test results include totals and percentages. In addition the morning test results are totalled and the percentages are calculated separately from the full totals.
The occurrences of hypoglycaemia are totalled.

Finally the percentage blood test results and percentage urine test results are displayed with the target set by the diabetic clinic.

9.3.9.3. Problem Advice

There are three parts to the problem advice section, the initial first stage decision to change the insulin dose, the follow up second stage if the outcome of the change was not satisfactory. Lastly backtracking which records the details of the recent related advice in order to allow the user to look at the record of recent insulin adjustment.

In order to identify the cause of the problem, the user must answer a number of questions, on their exercise and carbohydrate allowance. For example, the problem may be due to regular exercise and therefore it may not be appropriate to adjust the insulin dose. If during the question and answer session the cause is identified as being other than insulin, appropriate advice is offered. If at the end of the question and answer session it is necessary to adjust insulin, then first stage advice is displayed.

9.4. Summary

The interface has been designed for the novice user i.e. diabetic child or his/her parents or clinician who may become experienced in a short time.

The interface is flexible with all the text being stored in text files and are available to be amended.

The menu driver and all other parts of the interface are separate from the main system. The interface design has complied with Schneiderman's guidelines.

Lastly the system design including screens, function keys and methods of input, remain consistent throughout.

In addition to a well designed interface, the system must be flexible, particularly when the treatment for diabetes may change. In order that the system may cope with new insulin regimes, facilities must be provided to access and amend the techniques of management. Chapter 11 describes the clinician's system which offers facilities to amend diabetic management methods.

CHAPTER 10

System Modules and File Structures

10.1. Introduction: System Initialisation

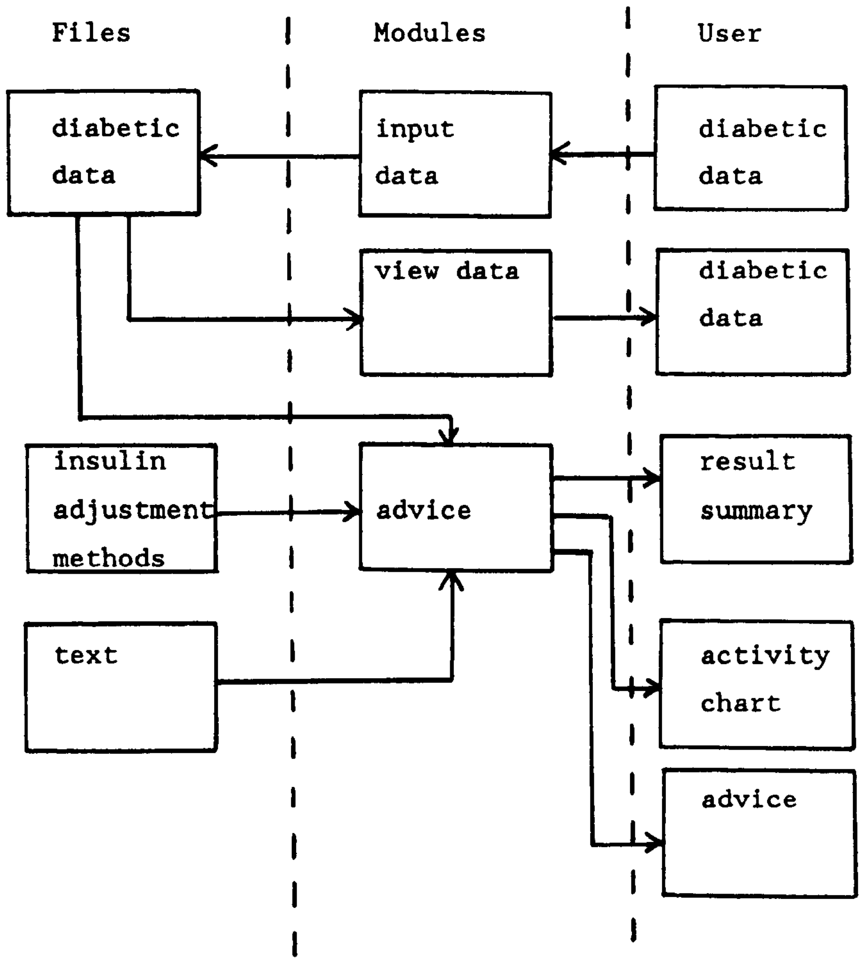
The aim of the Diabetic Management System is to provide advice for the individual diabetic following a particular insulin regime. The knowledge acquisition stage of this thesis produced a knowledge set of all management methods relating to all the current insulin regimes. In order to provide an individualised system, the user must initialise the system with his/her personal details. The information includes diabetic details such as the insulin regime and personal details such as name, age etc.

The initialisation program is run once only, in order to set up the system for a new user. The number of management methods is large and in order to maximize speed and efficiency of the file handling within the system, the rules relating to the diabetic user's personal insulin regime are selected from the whole set of methods available.

The personal details are input via a question and answer session and the system initialisation program is completely separate from the main Diabetic Management System.

The following sections describe in detail the structure of an individualised system.

FIGURE 23 Data Capture and Advice Modules



10.2. System Structure

There are seven system modules and this section describes the technical details of each module. Figure 23 illustrates the relationships between the three modules of data capture, view data and advice. Diagrams illustrating each module are in the appropriate sections. Initially the files utilised within the system are described.

10.3. Files

The system files serve several functions. The storage of data records which includes the data collected from the diabetic e.g. blood test results, and also the diabetic management methods which provides an individualised management algorithm. In addition the text files hold the text required by the system including screen text e.g. headings, user instructions, and advice text. The text files are vital in allowing the system to be fully adaptable to changes in diabetic treatment.

10.3.1. File Description

The files used for the system described in this thesis fall into two file types; text files and files of records.

The main text files are:

- advice text
- screen text
- help text
- general information text.

Each file consists of lines of text and associated numeric tokens. Each token within the file is unique and is used to access the appropriate text.

The record files are used to store data and diabetic management methods. Each data file consists of records which include the date of entry of information. The diabetic management methods are formulated in terms of numeric tokens linked to the associated text in the advice text files (see Appendix V).

Finally, a file of switches is stored so that the user may customise the system, that is switch off the introductory screen.

The main text files are listed below :

Screen Text

Each screen has a three digit numeric token for access.

Help Text

Organised sequential pages of text with a three digit numeric token (containing consecutive numbers) for access.

General Information Text

Organised sequential pages of text with a three digit numeric token (containing consecutive numbers) for access.

Advice text - two files

First stage advice text file

Second stage advice text file

Each piece of advice has an associated three digit numeric token for access.

10.4. Interface Module

The interface module contains a menu driven text selector, screen control and error handling procedures. The interaction of the interface module, system and user are illustrated in figure 24.

10.4.1. Menu Driver

The menu driver consists of two parts, the draw menu and menu control procedures. The draw menu procedure draws the menu on the screen, accessing its text in the text file. The menu control procedure allows the user to move the highlighted bar and select an option. The option selected is passed as a parameter to the main system.

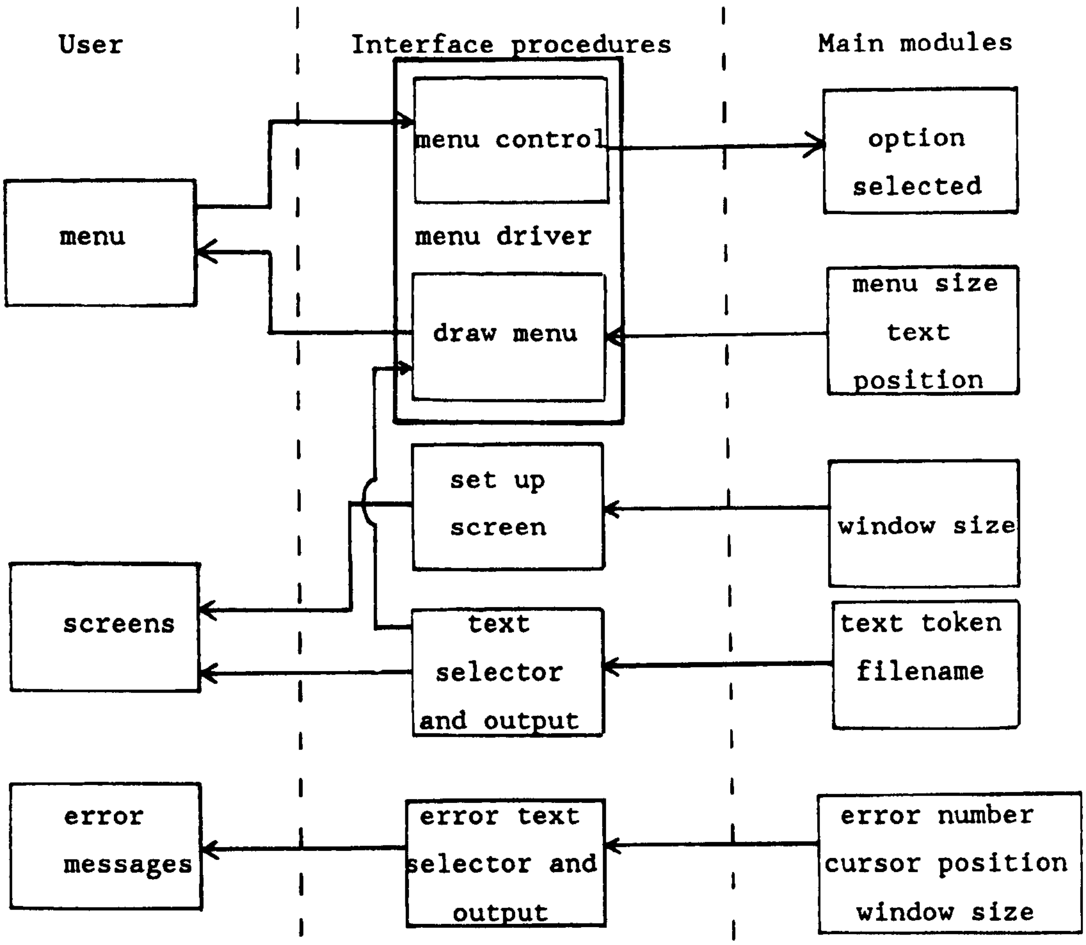
10.4.2. Set Up Screen

The set up screen procedure draws the screen with the relevant outline and text. The text is selected from a text file.

10.4.3. Text Selector

The text selector accepts a token and filename via its parameters. The procedure then accesses the appropriate text from the specified file and displays it on the screen.

FIGURE 24 INTERFACE MODULE



10.4.4. Error Text Selector and Output

When the user presses an incorrect key or enters invalid data the error selector procedure is called. The parameters that are passed are the start position of the message, the original window size and the original cursor position. The error message always appears on the same line.

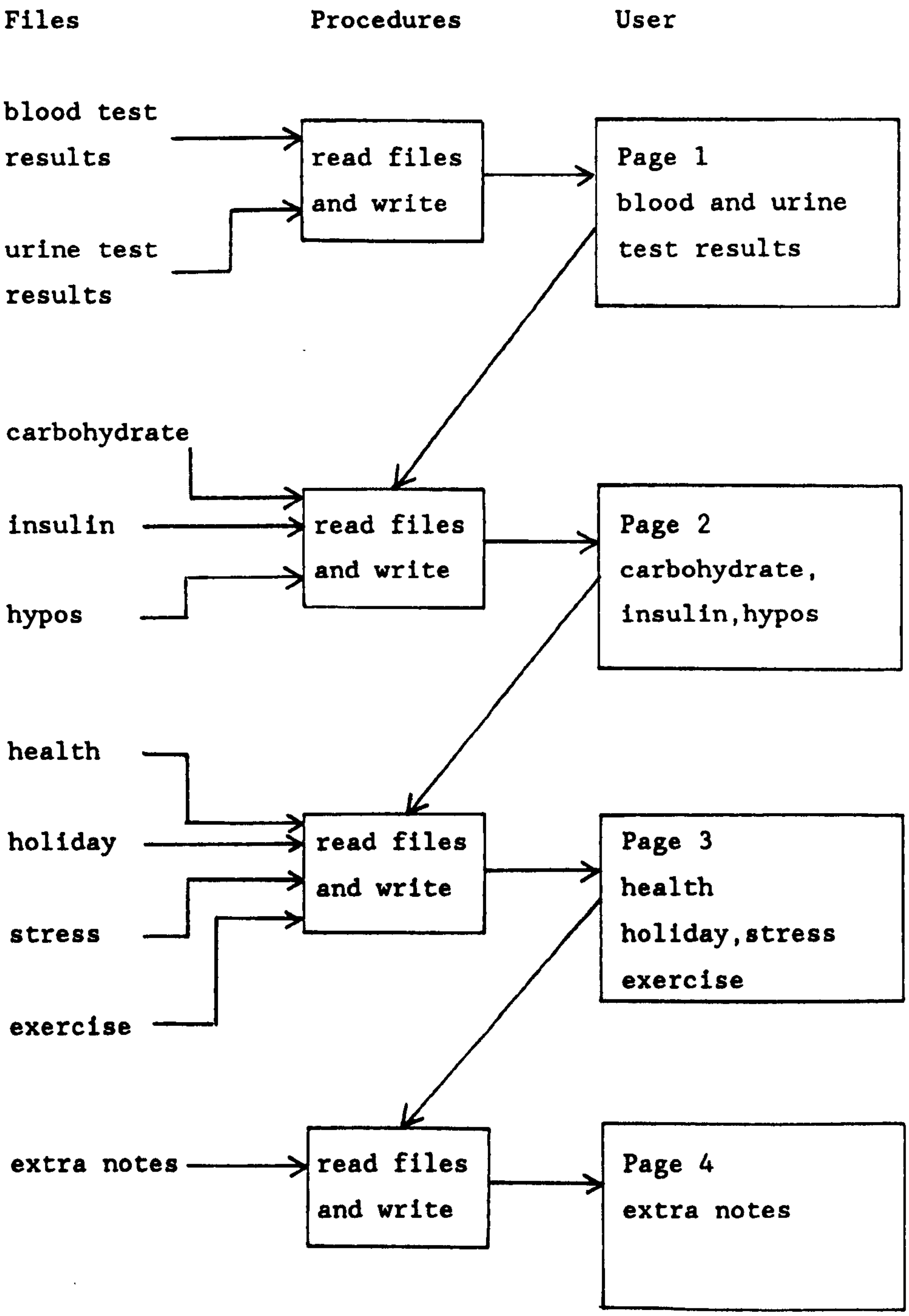
10.5. Data Capture

There are ten types of data that may be input by the diabetic (see Table 5, page 103 for a full list) The method for accepting this information is similar for each type of data.

The diabetic may add, change or delete information throughout the day. However, the user may only amend blood and urine test results after the current date. The user may view his/her blood and urine tests only or page through the rest of the recorded information.

The View data module is driven by the blood and urine test results and is illustrated in Figure 25.

FIGURE 25 View Data Module



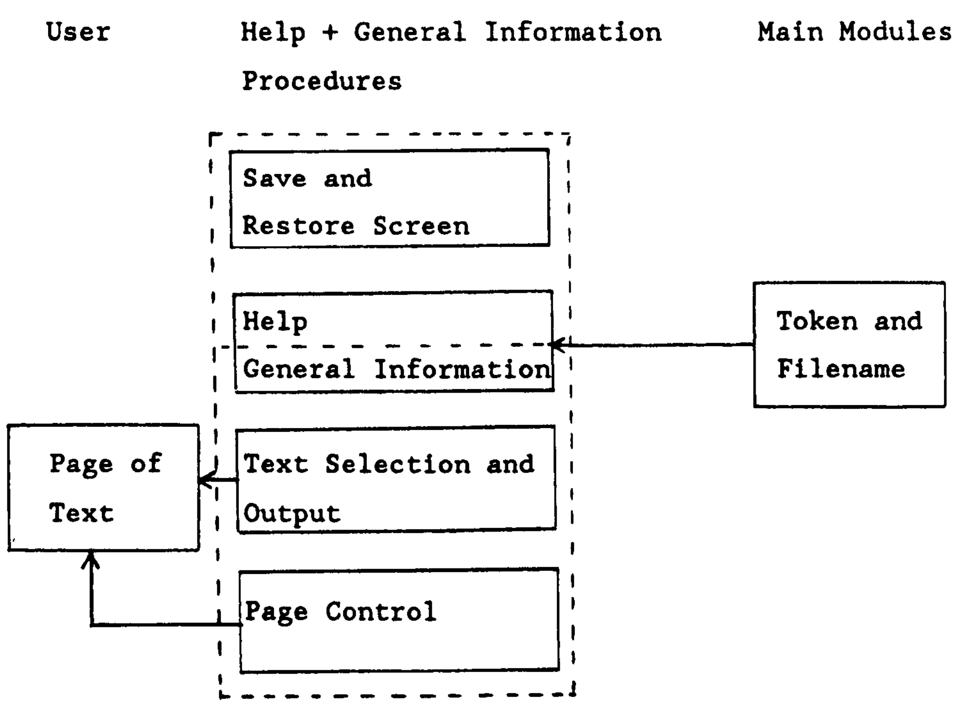
10.6. General Advice and Help Facility

The general advice option is accessed via the main menu and provides the user with pages of text about diabetes. The pages of text are stored sequentially with a numeric token associated with each page. This facility has common procedures with the help facility. Figure 26 illustrates the relationship between help and general information modules.

Help may be accessed at any time during the use of the system. When the user requests help, a numeric token is used to access the appropriate part of help. Each stage of the system has a numeric token associated with it.

The help facility saves the current screen and accesses and displays the appropriate text on the screen. The user may page forward or backwards. When the user escapes from help, the page of text where the help was requested is restored to the screen and the user continues with his/her task.

FIGURE 26 Help and General Information Module



10.7. Advice Module

The advice module consists of three parts, the activity chart, blood and urine test results summaries and specific advice.

10.7.1. Activity Chart

The activity chart outline e.g. time, headings etc., is selected from a text file and displayed. The time of injections and meal times are taken from the file and written on the screen.

The activity chart changes when the contents of the personal file changes. Therefore when the diabetic has a change in insulin regime for example, the activity chart will also change appropriately.

10.7.2. Blood and Urine Test Results and Hypo Summaries

The summary charts are provided by calculating the totals and percentages of blood and urine test results. The background headings are selected from a text file and are displayed on the screen along with the results. The number of hypos are calculated and displayed by a similar method.

10.7.3. Problem Advice

Specific advice on a particular problem (i.e. hypos or high blood sugar tests) starts by establishing that the problem is due to insulin rather than exercise or carbohydrate (Figure 29, page 121, shows a simple flowchart of the advice procedures). This is performed by a question and answer session with the diabetic. If the problem is due to another factor such as exercise, the appropriate advice is issued. This initial advice is selected from a small text file by a 3 digit numeric token (see Figure 30, page 122).

If the problem is found to be a result of insulin the type of problem and time of problem are then used to access the correct first stage advice text code (see Figure 30, page 122). The first stage advice code file contains a series of time spans, possible problems (i.e. hypo or high test results) and the associated advice codes (see Figure 28, page 120).

The code is used to access the correct advice text and to set up the follow up text codes. The follow up current text codes are a subset of the whole list of possible second stage codes, relating to the current problem. Figure 27 illustrates the interaction of advice files and advice production.

When the first stage advice has been displayed and the user has accepted it, the advice text is written to the backtrack file. Both the follow up second stage advice code file and backtrack files are work files for the current problem and they are initialised as empty entities at the start of a new problem.

If the user requires further advice on a related problem, for example, if the advice has been adhered to but the problem persists, then the current follow up file is accessed and the first code is utilized:

Current follow up file

File contents : 2 x 10 array -

advice codes

problem stops but opposite starts	problem persists
100	215
195	191
300	412
219	"
"	"
"	"

The code is used to access the second stage advice text file and once the user accepts the advice the code is wiped from the file.

Any further related advice is taken from this file and each code is deleted as it is used.

FIGURE 27 Data Flow Diagram to Illustrate the Interaction of Files and the Advice Produced.

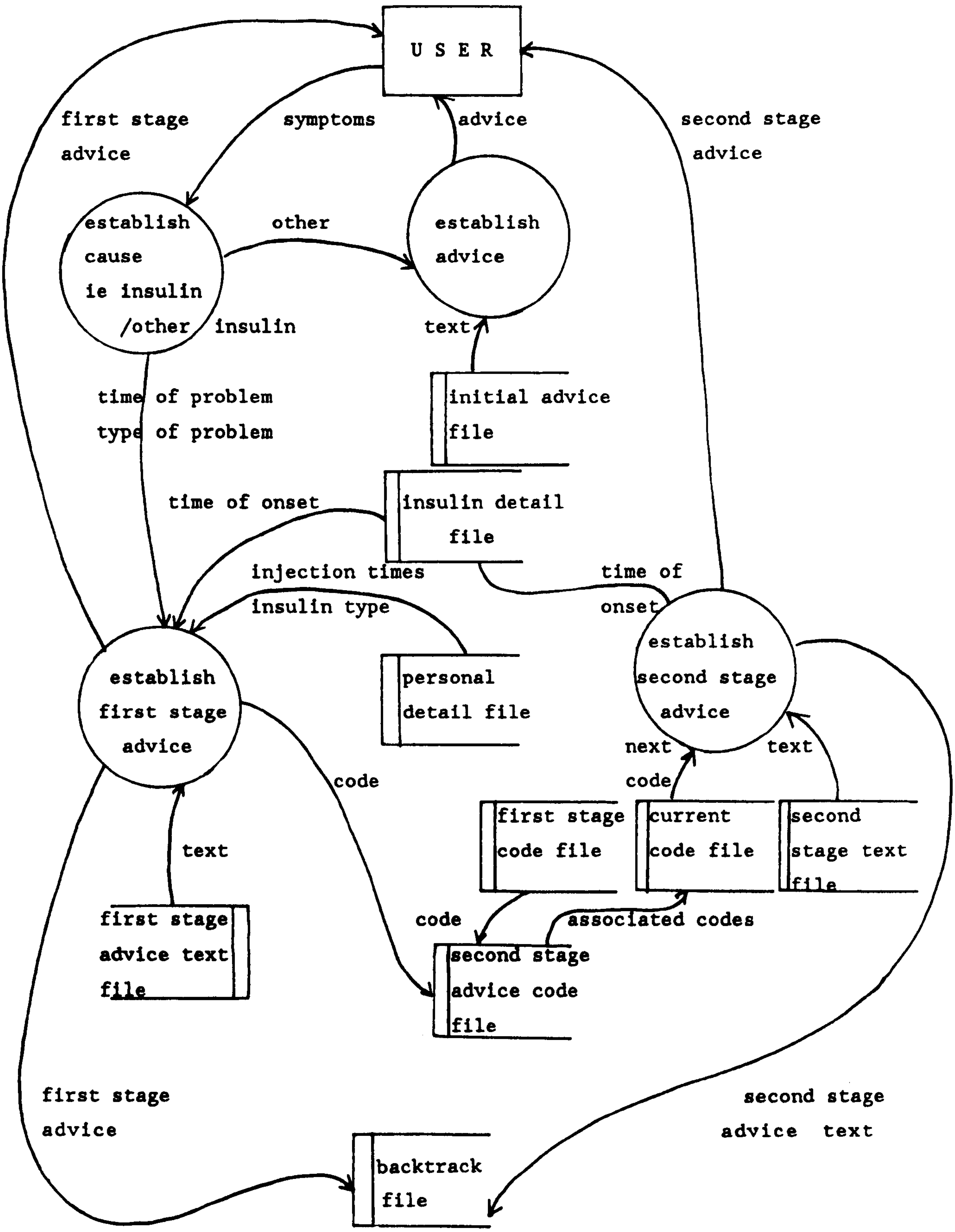


FIGURE 28 Specific Advice Module

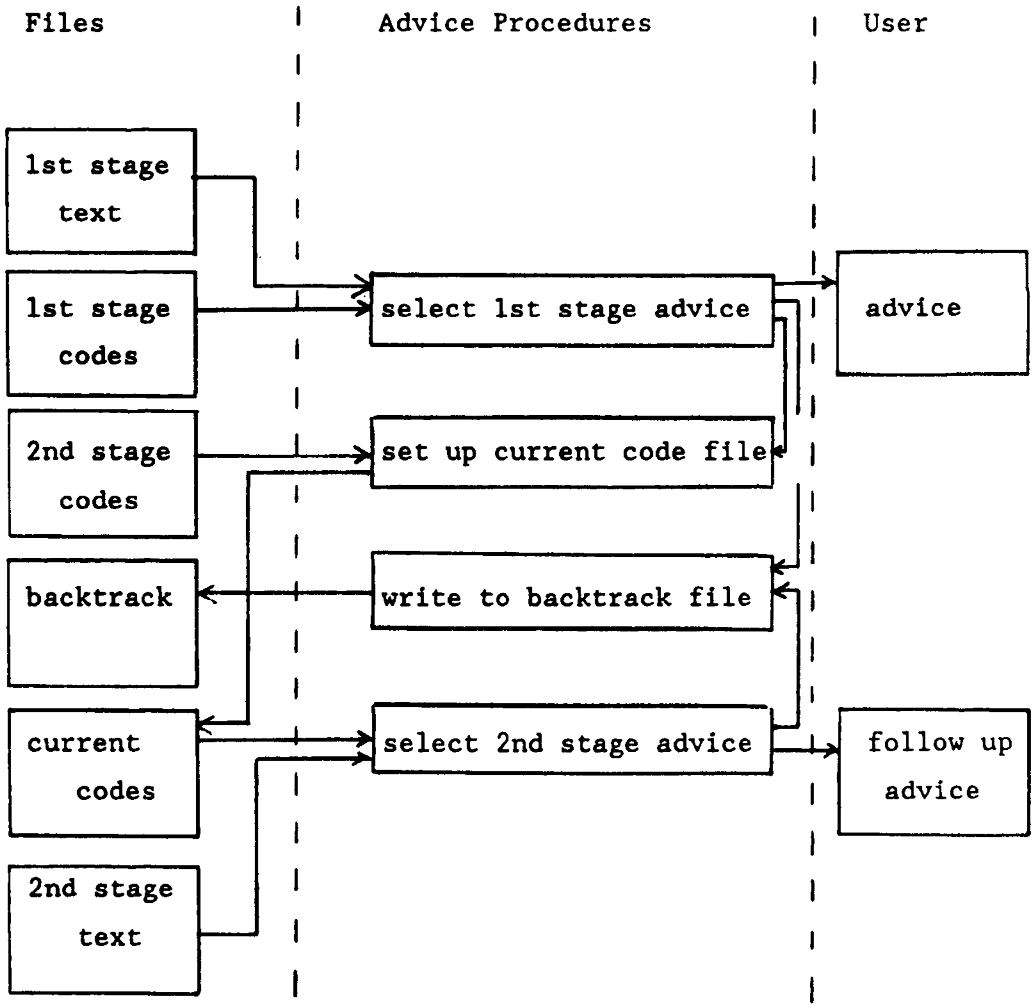


FIGURE 29 Outline Advice

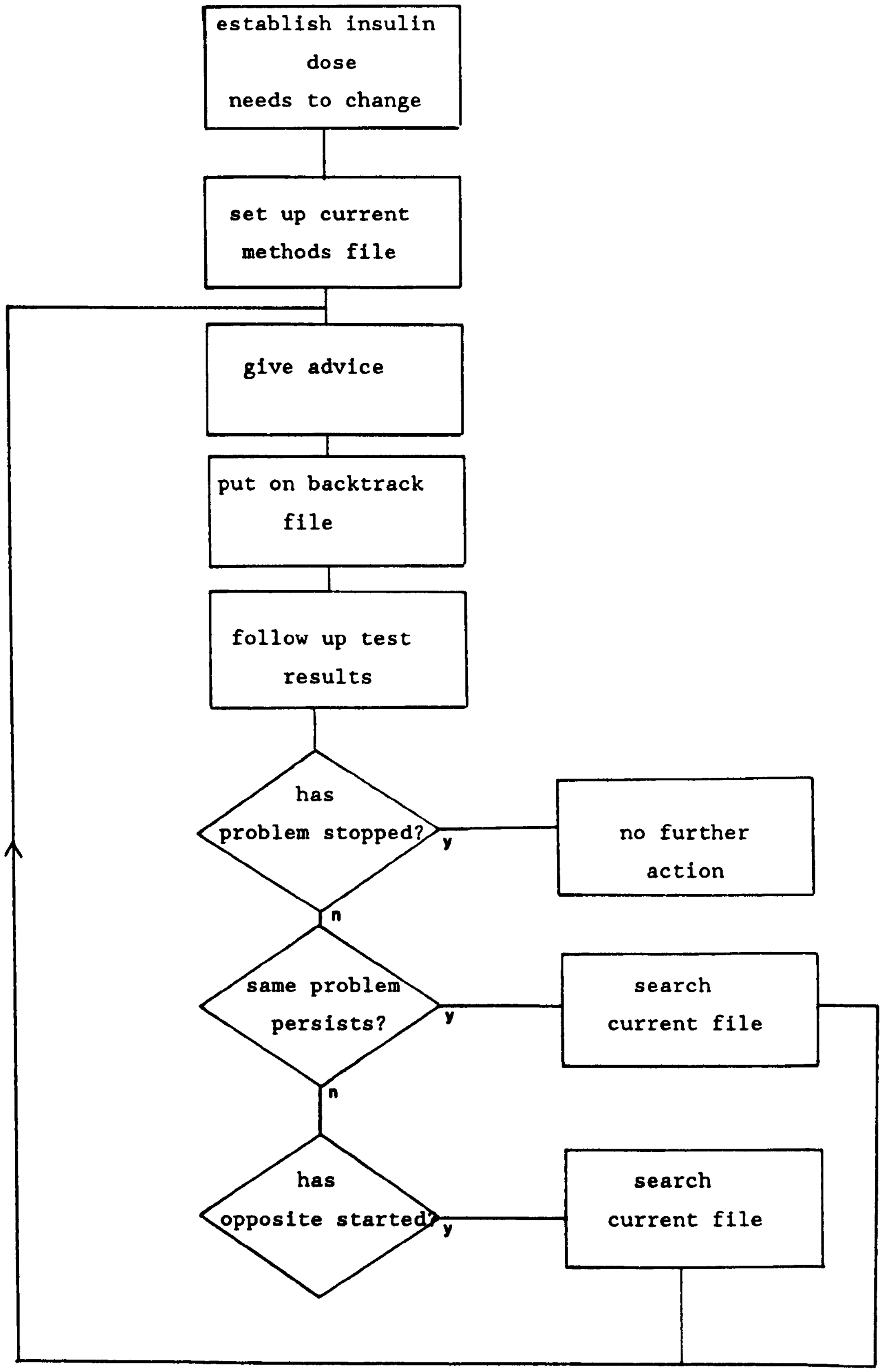


FIGURE 30 Advice Codes and Text Files

The data file for the first stage advice contains a list of the possible problem types and corresponding time span in which they occur. In addition, the advice code contained in this file is then used to retrieve the appropriate advice text from the 1st stage text file. The 1st stage advice code is also used for accessing the appropriate records in the 2nd stage data file. The 2nd stage data file contains follow up advice codes. Each record contains an identifying 1st stage advice code and a set of follow up advice codes which are used to retrieve the appropriate 2nd stage text.

DATA FILES | TEXT FILES

1st stage advice

problem type	time from	to	advice code	advice codes	advice text
hypo	T1+1	LT	001	001	Decrease insulin
hyper	T1+1	LT	002	002	Increase insulin
hypo	LT	T2+1	003	003	Decrease insulin
hyper	LT	T2+1	004	004	Increase insulin

2nd stage advice

advice code	follow up advice codes: opposite starts	problem persists	advice code	advice text
001	110	210	110	Decrease.......
	111	211	111	....
	112	212	etc.	....
	113	213		
002	120	220		
	121	221		
	122	222		
	123	223		

10.8. Summary

The whole system has been designed in order to allow the clinical user to adapt and change the diabetic system to meet the advances in diabetic treatment. This has been achieved by making all the text required by the system independent of the actual system. Most importantly the methods of diabetic management may be amended and in addition the associated text may be altered.

Therefore two systems are necessary. The diabetic system, providing data collection and advice for the diabetic child. In addition a clinician's system is necessary to allow the clinician to amend the advice section of the diabetic system 'tailoring' the advice and text appropriately.

CHAPTER 11

Clinician's System

11.1. Introduction

The clinician's system allows the clinician to adapt the diabetic management methods and the associated text. In addition it offers several facilities including generating of hard copy reports from an individual diabetic's data file and educational demonstrations of diabetic control problems (see Figure 31).

The change advice text and codes option offers the clinician flexibility and the ability to 'fine tune' diabetic management. The amended advice text and codes may be implemented on every file in use, or on selected diabetic patient files.

The advice text and codes may be amended if, for example, a new insulin is introduced. In addition further advice may be necessary and text may be altered to increase the accuracy of advice.

The insulin detail file may be updated to increase the number of insulins if necessary or an existing insulin may be deleted from the file.

Finally the write data option prints the diabetic data collected using the diabetic's data files. The option produces a hard copy of the data in a similar format to the diabetic diary.

FIGURE 31 Clinician's System Facilities

	Change Advice - Text
	- Codes
Clinician's Facilities →	Change Insulin files
	Print Diabetic Diary
	Help
Interface Facilities →	Interface - Menus
	- Screen Handling
	- Error Handling
	General Information
Demonstration and Educational →	Advice - Action Chart
	- Test Result Summary
	- Problem Advice

11.2. Clinician's Interface

The clinician's system's main options are amend advice text, advice codes and insulin details. In addition, hardcopy listings of the advice codes and associated text are provided. The clinician's facilities are fully supported with help.

The clinician does not require any technical knowledge of the system's programs or files. The clinician's interface has been designed to allow the clinician to amend the advice section easily. The clinician requires an understanding of the initial advice (first stage) and follow up advice (second stage), in order to make advice amendments.

The various facilities available within the clinician's system are now described in detail.

11.2.1. Amend Insulin Detail Files

TABLE 6 Insulin Detail File

Number	Insulin	Time of onset	End of action
1	RAPITARD	1 hour	5 hours

The insulin detail file contains a list of brand names and associated times of onset and end of action (see table 6). The clinician may wish to amend this list when an insulin is withdrawn from the market or a new insulin is introduced.

The option lists a maximum of four insulins per screen and the clinical user may amend or delete information or view more information.

11.2.2. Amend Advice

This section allows the clinical user to amend the advice text and codes. The advice involves two levels. The first stage advice establishes that the diabetic's insulin dose must be altered. The second stage advice follows up the outcome of the first stage advice.

The possible outcomes being :

1. The problem is solved and no further advice is necessary.
2. The problem persists.
3. The problem stops but another starts as a direct outcome of the first stage advice taken.

The structure is such that the first stage advice code refers to the first stage text file and the appropriate second stage follow up codes. Each second stage follow up advice has two sets of advice codes which refer to the second stage text file. These two sets correspond to advice that is generated according to whether the problem persists or stops but another starts. This structure is detailed in Chapters 9 and 10.

During both amend advice codes and advice text the clinical user has access to three sections each presented on a single page. A heading indicates which option has been selected and the information that may then be amended. In addition the information to be amended appears in an outlined window (see Figure 32 and Figure 33). It is important to note that the advice codes define the algorithmic approach (management methods) to diabetic management and the advice text is the actual advice text presented to the user. When the clinical user changes the advice codes, major changes are being made to the structures providing diabetic advice. The amend text facility is provided to allow the user to 'fine tune' the wording presented to the diabetic.

11.2.2.1. Amend Advice Text

This option allows the clinical user to update and alter the wording of the advice. The user is warned before entering the amend advice text option that each code may be used more than once and therefore care should be taken when amending the text to ensure that the wording is appropriate for all occurrences of the code. This means that the overall control strategy for a diabetic problem remains the same but the text presented to the user is amended.

The first page of the option lists the possible advice codes for the first stage advice. The user may move on to examine the first stage codes for another insulin regime or select a particular first stage advice code.

If the clinical user enters an advice code the second page displays the text for that code and includes a list of follow up codes (second stage advice codes). The user may amend the text or escape out of the current window (see Figure 32) and enter a follow up advice code.

The follow up advice (second stage) text is displayed if the user enters a follow up code. The text is outlined and the user may alter the text or move to other parts of the files (see Figure 32). The user may move around the files examining the contents by using escape and return keys.

FIGURE 32 System Screens : Change Advice Text

Page 1

First stage advice codes

Regime: 2 mixed injections

Type	Time from	to	Advice Codes
hypoglycaemia			103
hyperglycaemia			121
			321

to menu

ESCAPE RETURN ADVICE CODE

to next regime

Page 2

First stage advice text

advice code: 121

escape

Advice: ....

Reason: ....

Follow up codes:

persisting problem: 233, 212 ....

stops but opposite starts: 344,491 ....

back to Page 1

to menu

ESCAPE AMEND DELETE RETURN ADVICE CODE

Page 3

Second stage advice text

advice code: 233

escape

Advice: ....

Reason: ....

back to Page 2

to menu

ESCAPE AMEND DELETE RETURN

11.2.2.2. Amend Advice Codes

This option allows the user to update and alter the advice codes and thus change the control strategy for a particular diabetic problem The amend advice text and code facilities have been designed so that they follow a similar structure allowing a standardisation of the interface.

The first page of the option lists all the possible advice codes for the first stage advice of a particular insulin regime. The advice codes appear in an outlined window and the user may amend the code or escape from the current window. The user may enter an advice code or move on to examine another insulin regime.

If the user enters an advice code its text appears on page two and includes the corresponding follow up advice codes (see Figure 33). The follow up (second stage) codes appear in an outlined window and may be amended by the user. If the user escapes out of the window he/she may enter an advice code, in which case it appears on page three of the option. The user may do this if he wishes to check on the corresponding text before he alters a code.

Page three displays the text and does not allow amendments. At this stage the user may return back to page two or escape from the option. Similar to the amend text codes option the user may move around the files using return and escape.

FIGURE 33 System Screens : Change Advice Codes

Page 1

First stage advice codes

Regime: 2 mixed injections

Type	Time from to	Advice Codes
hypoglycaemia		103
hyperglycaemia		121
		321

change codes in window

to menu

ESCAPE   RETURN   ADVICE CODE

to next regime

Page 2

First stage advice text and follow up codes

advice code: 121

Advice: ....

Reason: ....

Follow up codes:

persisting problem: 233, 212 ....

stops but opposite starts: 344,491 ....

back to Page 1

to menu   escape

ESCAPE   RETURN   ADVICE CODE   change code in window

Page 3

Second stage advice text

advice code: 212

escape   Advice: ....

Reason: ....

back to Page 2

to menu

ESCAPE   RETURN

11.2.2.3. Hardcopy Listings

Listings of the complete set of advice codes and corresponding advice text are available. The format of the listings is structured in a similar way to that of the amend advice text and codes option. The clinical user will find such listings essential when making major changes to advice codes and text.

In addition they provide a quick reference guide when the user needs to view information but does not want to change the screen he/she is currently using.

11.3. Report Generation

FIGURE 34 Sample Diary

Date	urine test results	blood test results	insulin	carbohydrate
1.1.90	3,2,1,0	7.30 am - 9	13 5	20 15 35 15 40 10
		1.30 pm - 13	9 4	
		6.45 pm - 5		

Extra information
Holiday
Cold

END OF REPORT

The write data files option provides a hard copy of the diabetic data. This option requires the diabetic's disk so that the files may be printed. The data is printed out in a similar format to the diabetic diary (see Figure 34). At the end of the report the test results are printed out in a summary report of totals and percentages. In addition, the dates of days with hypos are listed with the numbers of hypos totalled.

11.4. System Initialisation

When the clinical user has amended the advice code and text files it will be necessary for the diabetic user to initialise his/her system again. The system initialisation program will select the appropriate parts of the file that are related to the diabetic users own insulin regime. The system can then utilise the latest files in order to advise the diabetic on any problems with hypoglycaemia or high test results.

11.5. Summary

The clinician's system supports facilities to amend both advice codes and text allowing the system to change as diabetic treatment advances. In addition, this facility provides scope for the clinical user to amend the advice section, tailoring the text to his or her own requirements for treating diabetic patients. The clinician's system is comprehensive and includes help facilities etc.

The design of both the diabetic system and the clinician's system is independent of machine type and programming language.

CHAPTER 12

Implementation

12.1. Introduction

There are a wide range of personal computers currently available. The prices range enormously from approximately £100 to several thousand pounds, depending on the hardware specification of the machines. In addition there are numerous software packages available for personal computers including programming languages, integrated packages and expert system shells.

In order to choose the most appropriate machine and software to develop the diabetic management system the requirements of the system specification should be considered. The machine must provide memory able to cope with the size and number of files involved (see Section 12.4.1). In addition a twin disk drive is necessary for efficient implementation. The software must allow the production of a robust, fast, easy to use system that is portable.

This chapter justifies the choice of machine and software. In addition the organisation and size of the system text files and data files in the implementation are described.

12.2. Choice of Machine

The specification of the machine for which the system was implemented is described in Section 12.2.1. Such a twin floppy PC is available at a cost of approximately £500. More powerful hard disk machines are available at extra cost and would prove beneficial for the clinician's system: Portable machines of similar capabilities are available at very little increase in price.

12.2.1. Machine Costs

The table below illustrates the approximate price of a machine for the home and the machine and printer suitable for use by the clinician.

TABLE 7 Approximate Price of Machine

Hardware Specification	Price
Home-based computer system	
Amstrad 1640	
twin 5¼" floppy disks	
with monochrome monitor	~ £500
Clinician's computer system	
IBM model 30:	
with 20 Mbyte hard disk	£1299
with 40 Mbyte hard disk	£1429
Epson LX800 printer	£195
and cable	£ 13

12.3. Choice of Language

The chief requirements for a language to develop this system is that it must be fast, inexpensive and readily available. The system required simple file handling but good data structures for the file records were essential.

Turbo Pascal 4.0 was chosen for system development because of its integrated environment and speed of compilation. In addition it offers substantial supporting software, many standard procedures for screen handling and allows easy access of the operating system. These features are not standard in other versions of Pascal.

A procedural structured programming language was required to allow the system to be transferred to another programming language if necessary. Although the system was developed in Turbo Pascal 4.0, it's design is such that conversion to another language would present the minimum of difficulty.

12.4. Design

In order to maximise the efficiency and speed of the system, in particular the response time, the diabetic management system utilises the management methods and text files appropriate. The system initialisation program initialises the system with the personal details for the user and sets up the appropriate management method and text files (see section 12.4.2. for files sizes) in order that the system may issue the appropriate advice. The details of the software design are fully described in chapters 9, 10, and 11. The system comprises of 2 disks which will run most efficiently on a twin floppy machine but will also run on a single floppy machine.

The two disks required for the system are:

Disk 1 - Systems disk
- system software
- advice files
  (management methods and text)

Disk 2 - Diabetic data disk
- containing all the recorded details of diabetic data.

12.4.1. System Initialisation

The system initialisation program takes the individual diabetic data and extracts the appropriate individual diabetic management algorithm from the full set (refer to Figure 34). The full system requires 3 disks (refer to Table 8 and 9) but only two disks are necessary after initialisation.

FIGURE 35 Initialisation of Diabetic's System

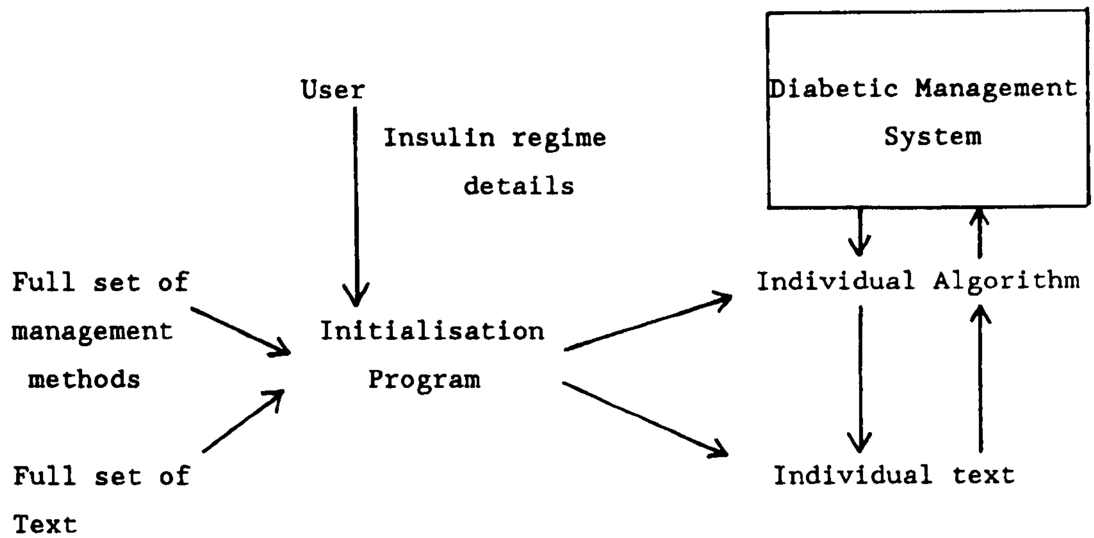


TABLE 8 Organisation of Files on the Three System Disks

DISK A	DISK B	DISK C
- Full set of management methods	- individual algorithm	- diabetic data files
- Full set of text	- individual text	
- Initialisation program	- diabetic management system	

12.4.2. System File Statistics

The approximate size of each file is listed below.

TABLE 9 Organisation of Data and System Files

Diabetic Management System		
Full Set of Diabetic Management Methods (before initialisation)	:	50K
Advice text file	:	100K
Initialisation code	:	20K

Individual Diabetic Management System		
Program - code	:	100K
- text	:	20K
Advice - management method files	:	10K
- text files	:	20K

Clinicians System		
Program - code	:	90K
- text	:	20K

12.4.3. Module Sizes

The diabetic management system is split into several modules :

Module Function	Size
data structure declarations	15K
advice	25K
display data	15K
interface (screen handling, errors)	11K
menu driver	7K
help and general information	7K
data input	25K
Total	~ 105K

The clinician's system includes the above module (except data input and display data) and has two further modules :

change management methods and text	:	25K
print diary	:	7K

12.5. Disk Space

The following files held on the system disk will not increase in size:

System file
Management Methods
Text

The files held on the diabetic data disk will increase each day by the following:

blood test results	66 bytes
urine test results	30 bytes
insulin details	14 bytes
carbohydrate	18 bytes
hypoglycaemia	30 bytes
stress	10 bytes
health	12 bytes
holiday	8 bytes
exercise	16 bytes
extra notes	290 bytes

The total maximum disk space required for 14 weeks data collection (between clinics) would be 48412 bytes and fits easily onto two 5¼" floppy disks or one 3½" disk.

12.6. Summary

The system has been implemented using Turbo Pascal Version 4 on an IBM compatible PC. The most likely system to be used is the AMSTRAD because the price is relatively low. The design of the system software is such that it could easily be converted to another language if required.

CHAPTER 13

The Diabetic Management System : Conclusion

13.1 Diabetic Management : A System Review

The initial objectives of this thesis were to identify the methods of diabetic management and appraise the systems available to aid such management. The review highlighted the inadequacy of a number of management aids including blood glucose meters and insulin adjustment algorithms (Smith et al,1985, Albisser et al, 1986). The need to develop a home based microcomputer system to offer advice for the insulin dependent diabetic child was identified.

The method of diabetic management utilised by this system involved two stages. An initial stage advises on insulin adjustment and the second stage deals with the follow-up of the action taken. This feature has the advantage of relating current diabetic management problems to action taken for a previous problem.

The system is implemented on an inexpensive microcomputer using low cost, easily available software. It is able to adapt to the individual diabetic treatment. The user interface has been designed for the naive user and is menu driven. In addition it is adaptable for the experienced novice. It is designed primarily for the older diabetic child or the young diabetic child and parents. Special areas on the screen have been designated for particular functions e.g. help, input etc.

The system aims to provide several educational aspects for the diabetic. The system interrogates the user prior to offering advice on insulin adjustment. The advice section offers a reason for the advice given, providing a reinforcement of the management guidelines. The backtrack file contains a history of the current problem including dates and advice given. The general advice section provides information for the diabetic on general aspects of management and care for the diabetic.

Clearly, a system such as this must have fail-safe procedures when advising the diabetic. The system interrogates the user in order to establish whether insulin should be adjusted and if the system cannot identify the problem the diabetic is advised to contact the doctor. In addition similar advice is offered if, after several attempts, control problems persist. Finally, there are many reminders to the user that the health visitor should be contacted when problems persist.

The advisor system offers facilities for capturing diabetic data, general information on diabetes and individual advice on diabetic problems. The facilities available within the system clearly need evaluating for usability and acceptability by a sample of end users.

Legal problems arise when attempting an evaluation of this system because it is a medical advisor. In addition, this system is to be based in the patient's home offering advice on the patient's diabetes, in particular the adjustment of insulin. This category of system requires careful consideration of both ethical and legal implications associated with computer aided medicine before the evaluation can proceed.

The evaluation of this system must be geared towards the end user i.e. the diabetic and their family. The initial stage requires user feedback on the adequacy of advice, reliability of software and acceptability. This chapter considers the various methods of evaluation of clinical decision support and the associated legal and ethical problems. The methods employed to evaluate this system are described in detail. Finally, the results of the evaluation are discussed including the conclusions drawn from the initial user feedback.

13.2 Computer Aided Medicine : Ethical and Legal Issues

There is a growing amount of literature devoted to the ethical and legal aspects of computer-aided medicine. However, much of the literature is devoted to computer-aided decision support particularly expert systems designed for the sole use of the clinician. The Diabetic Management System utilises an algorithmic approach to problem solving for diabetic management providing a decision making aid for diabetic children and their families, based in their home and so presents different legal problems.

The ethical and legal issues must be considered at two stages of the Diabetic Management System implementation. Firstly, the evaluation of this system will take place in the home of the diabetic. Before evaluation may proceed, both the ethical and legal issues must be discussed. Secondly, the system will be implemented in the home of the diabetic without clinical supervision presenting an arguably unique situation for a medical advisor and its associated ethical and legal implications.

Although this subject is discussed in the literature, it is based on theory rather than practice as neither the manufacturers or authors of this type of system have been sued at court. Much of the literature reported in journals is based on American Law however, similar legal considerations are relevant in British Law (Reed C, 1990).

13.2.1 Discussion on the Ethical Issues of Medical Decision Support Systems

The evaluation of a medical decision support system is likely to mimic the approach involved in drug evaluation (Speigelhalter, 1983). It is therefore necessary to consider the ethics associated with the evaluation of new drugs and the clinical trials such products are required to undergo. Much has been written about the assessment of ethical issues relating to medical research and the guidelines associated with clinical trials are outlined by Pocock (1984), which are described below.

In brief, some of the ethical issues relating to clinical trials include that the research involving human subjects must conform to generally acceptable scientific principles and the experimental procedure should be clearly formulated. The research should be conducted by scientifically qualified persons and *under the supervision of a clinically competent medical person.*

The trials cannot legitimately be carried out unless the importance of the objective is in proportion to the inherent risk and the evaluators have assessed the predictable risks in comparison with foreseeable benefits to the participants of the trials. The privacy of the subject should be protected and the impact of the study on the subject's physical and mental integrity should be minimised. *The trials should not continue if the doctors involved are not satisfied that the hazards are predictable.*

Each potential subject must be informed of the aims, methods, anticipated benefits and potential hazards before giving consent. No consent should be accepted if the subject is in a dependent relationship with the doctor and/or under duress. Permission in the case of the subject being incapacitated should be obtained in accordance with national legislation.

Finally, the doctor has an obligation to preserve the accuracy of the results and the research protocol should contain a statement of the ethical considerations.

Some general discussion points on the ethics of computer aided decision support have been raised by Speller and Brandon (1986), who identify dangers of new systems on two levels :

- First and more direct is where the system makes the decisions and controls the process without human consultation.
- Second and more subtle, is where humans religiously obey the System, implementing its decisions without understanding the significance and credibility of their actions.

However, Victoroff (1985), when considering bioethics states that many criteria that indicate readiness for an expert system are satisfied :

1. There are experts in the field who possess specialised knowledge in the field by which they can achieve better results than a non- expert.
2. These experts are in limited supply.
3. There are a reasonable number - but not excessive number - of basic principles and rules, on which most experts agree.
4. The knowledge in the field is valuable.

Mortimer (1989), also discusses the benefits and potential hazards of medical decision support systems and states that the utilization of computers in medicine has brought increased accuracy, efficiency and life-saving technologies to this area of science. However, computer-aided medicine can also contribute to an increased risk of injury, particularly when humans rely on computers too much. Diagnostic expert systems, which mimic the cognitive methods of experts, are especially vulnerable to over-reliance.

In addition, Victoroff (1985), outlines 'ethical debugging' the guidelines that should be adhered to before any expert medical system is employed. In brief the guidelines state that the system should pass both Human Subjects Committee and Institutional Ethics Committee reviews. The following questions should be answered beforehand :

1. Does the system weigh treatment options?
2. Does the system entail risks?
3. Can the system be made available fairly to all who might reasonably benefit from it?
4. If the system is a prototype, have candidates for trial been selected without discrimination or capriciousness?
5. Does the system operate "transparently", to any extent? Assure human oversight.
6. Was the system designed by specialists? Consider a review by family practitioners.

7. Can the system justify every conclusion, to the user? Auditing should be built in.

It can be noted that several of Victoroff's guidelines are similar to those specified by Pocock.

By discussing the ethical issues relating to medical decision support it is possible to identify the areas within the evaluation and implementation of this system that require particular ethical consideration.

The evaluation of the Diabetic Management System has obvious difficulties because it is a home based system. Its special feature being that it provides individual advice for a particular diabetic regime to be used by the diabetic at home. For an evaluation in the home to be ethically acceptable continuous supervision and monitoring by a clinician will need to be provided.

Each diabetic follows a different regime and once the system is set up for a particular diabetic it cannot be used by another diabetic. The advice that may be issued is based on the diabetic's regime and the recorded information (blood test results etc). The interface has been designed for the unsupervised use of the novice user but this type of system is clearly at risk from inadvertent misuse by the user. This presents a complex ethical/legal problem that requires careful consideration.

It is clear that associated with the ethical considerations of any evaluation there are a range of legal issues. The legal issues that surround the evaluation and introduction of medical expert systems will be discussed in the following section.

13.2.2 Discussion on the Legal Issues of Medical Decision Support Systems

The main issue when considering the legal implications associated with this system is establishing who will be liable in the event of adverse health care as a result of using the system (Cambell, 1984, Expert System User, 1989 b, Wyatt, 1990). Most of the literature considers hospital based diagnostic aids for the physician's use. Few consider a mass produced general diagnostic aid for use in the home. None consider a system comparable to the Diabetic Management System that would be used at home but tailored to the individual user offering advice based on their treatment and lifestyle.

In order to establish liabilty it is necessary to identify the law that would be applied if a system user decided to sue because of adverse health care (Hyman, 1988). Software may be classed as a product where strict liability would be imposed, or a service where professional misconduct or negligence would be imposed (Cook & Whittaker, 1989).

Zeide and Leibowitz (1987) state that since teams of experts and programmers produce expert systems, it is difficult to prove negligence by any one person, leaving injured users out in the cold. However, viewing programs as products eliminates the need to prove negligence. In light of public policy considerations and since courts may view expert systems as unreasonably dangerous products (especially in fields like medicine, finance and space), the law will probably hold manufacturers responsible under strict products liability for injuries caused by system defects (Stamper, 1988).

Strict liability is liability without regard to whether the defendant was neither negligent or blameworthy with regard to the act charged as wrongful. The liability for the harm caused is absolute. Defences sometimes raised against strict liability are that the danger involved was sufficiently obvious that the plaintiff was unreasonable in exposing him/herself to it or that the plaintiff misused the product(Cook & Whittaker , 1989).

Tort is a civil wrong other than a breach of contract. Torts include negligence, defamation and invasion of privacy. Negligence is the most complex tort.

Negligence occurs when :

1. Person A owes some duty or obligation of care to person B (a duty)
2. Person A neglects that obligation or breaches the duty of care (a breach of duty)
3. Person B suffers injury or harm (harm).
4. The harm is caused by that lack of care (caused by the breach of duty).

The term 'duty of care' is often referred to in legal text and the customary standard in proving negligence is that of 'a reasonable, prudent person'. Malpractice is an application of the law of negligence and liability is usually imposed when a professional fails to exercise reasonable care (Cook & Whittaker , 1989).

Determination of whether medical decision support systems are a product or service is a difficult issue. For an item to be classified as a product, it must be tangible and must be able to be owned. The physicians' acts of making a diagnosis and of providing therapy have previously been classified by courts as services. Whether a judicial system will treat a given diagnostic system as a product or service is in part determined by the producer or seller's degree of involvement with the buyer and/or injured party. If the software is mass marketed to patients directly, then ownership of the system rests in the hands of the patient, and strict product liabilty may well be applied when patient-owners suffer injuries (Miller, 1989).

Mortimer (1989) states that for policy reasons, professional medical expert systems and in-home diagnostic systems should be considered products when sold as individual hardware systems to hospitals and consumers. Strict product liability should apply to manufacturing defects in the programming and production stage. Mistakes in actual design of the program should be analysed under a negligence standard. A negligence or professional liability theory should apply when a physician intervenes and improperly uses or relies upon an expert system. Negligence or professional liability also is appropriate where a programmer custom designs an expert system for a particular hospital or physician and breaches the duty of care in designing the program. Miller (1989) also includes the following with regard to professional malpractice, 'the patient may sue the physician for malpractice in providing substandard care, and the physician may in turn sue the seller or manufacturer for providing a faulty service or product'.

Liablity analysis for in-home expert systems is much less complicated than that of profesional systems used by physicians and hospitals. There is no professional service provided; there is only the purchase of a "mass produced" computer program. Numerous injuries could result from these systems. For example, a consumer could be injured by a manufacturing defect in the program that misdiagnosed his symptoms or misinformed him that his symptoms were minor when in fact he needed immediate care. An additional problem might occur when the system misinforms the consumer in an emergency situation.

Injuries resulting from manufacturing defects in these expert systems probably would be subject to strict products liability. This lessens the plaintiff's burden of proof. Otherwise the plaintiff would not be able to specify the defect in the program under a negligence standard. With a strict products liability standard, all parties in the distribution chain - manufacturers/programmers and distributers - would be strictly liable. If, however, the defect were found to be in the program design, the courts may hold the manufacturer/programmer to negligence standard only.

When determing whether a medical expert system should be considered a product or service, Mortimer (1989) identifies three ways that an item reaches the consumer :

1. The medical expert system is specifically tailored for their use.

Mortimer assumes that direct consumers of specifically-tailored medical systems would be physicians or hospitals, not patients. Because such expert systems would be developed based on the specific needs of a hospital or physician, it would be designed for their particular use only. Since the product is sold to one user, the supplier is not in a better position than the user to bear the costs of defects. The programmer is not selling 'en masse' and cannot spread the cost of the defect over a number of consumers on the same scale as a mass producer. The limited application of this type of system makes it more like a service than product, and the appropriate liability is negligence.

2. The medical expert system is not tailored to the user's specific needs.

This would apply to in-home diagnostic medical expert systems that are mass produced as well as to diagnostic systems such as INTERNIST or MYCIN, which hospitals and physicians use. "Ready to use" expert systems represent a method of distribution analagous to mass distribution of any product. The objective is to sell the identical program to as many consumers as possible rather than to one particular user.

Strict liability would be applied to this type of system. If the system is defective, the supplier is creating a risk of harm and receiving a profit. Patients and doctors have comparatively little knowledge of the system's internal structure and rely on the supplier's expertise. The supplier is in a better position both to anticipate the risks and to bear the costs of an injury. The supplier can calculate costs into the price of an expert system. On the other hand, Mortimer (1989) argues, because medicine is not foolproof, why hold a producer that "practices medicine" to a standard higher than the professional's standard ?

3. A hybrid of types one and two.

Professional medical systems used by physicians fall into this category because both a service (the physician's professional judgement) and a product (the expert system) are involved. Injury can result in two ways :

- a defective program is used while providing a service
- a correctly manufactured program is used, but is misinterpreted or relied on improperly

Categorising the transaction as hybrid leaves the standard of liability (negligence or strict liabilty) undetermined. This provides leeway for the courts to use discretion in complicated situations where varying standards might be appropriate.Those expert systems that are intended for general in-home use do not fall into this category, because no additional service, such as by an intervening physician, is rendered once the program is reproduced for mass distribution.

When determining the standard of liabilty when a defective hybrid product is used while providing a service , the courts generally examine three elements :

1. the nature of the activity
2. whether the defective product was physically conveyed or merely used in providing a service
3. whether the service or the product was the primary focus of the bargain

The sale of a product carries with it an implied warranty that the product is reasonably fit for its intended use. This creates a duty to warn the ultimate user or consumer of an unsafe product. Since it usually is impossible to completely debug a program, the manufacturer must warn of possible defects. Nondisclosure of such a risk alone can put a product in a defective condition. Warnings should be plain and explicit, but this may be difficult or impossible when it comes to unpredictable bugs. The inadequete warning itself might make the expert system 'defective'.

Miller (1989) includes the point in his paper that 'Provisions of adequate warnings to users can lessen the chances that a manufacturer or seller will be strictly liable for damages to users'. In addition it is stated that in the case of a patient owning a diagnostic aid ' the patient, as the owner of a faulty product, would directly sue the manufacturer. The courts will also recognise that an otherwise safe system can be misused by the physician or patient who uses it'.

However ,Clark (1988), states that because the law is always uncertain, and ever changing, the pioneers of any new technology face some degree of risk that the law will not recognise their presumed protections, or will retrospectively impose unexpected responsibilities, and hence liabilities. Thus reminding us that, until such cases are taken to court a certain degree of risk is involved in the production of medical decision support systems.

Cannataci (1989) considers a development in the field of product liability that could have an effect on the liability for mass-marketed expert systems in Europe is the EEC's Commission Directive 85/374 of 30.5.85. It imposes the principle of strict liability throughout Europe, with a not inconsiderable effect on the liability laws of some of ' the twelve member states '. For example, 'this imposes liability without fault, and so places a much heavier burden on the producer than the English law of negligence does'(DTI, 1985). The DTI, in its published document states that ,whilst recognising that the directive does not appear to extend liability to the providers of faulty information , the view expressed is that it is important that liability be extended to the manufacturer of a machine which contained defective software and is therefore unsafe.

By discussing the area of law that would be applied to medical decison support it is possible to make some conclusions on the legal liabilty that would be applied to the Diabetic Management System described in this thesis. The system is a home based system designed to offer advice to the individual diabetic. Although the program supplied to the user would be mass produced, each system offers advice based on the individual owner's information i.e. personal details, blood test results etc. The system does have a warning included in the personal advice section of the system stating that the advice issued in that section is for the diabetic owner alone and cannot be used by any other diabetic.

It can be concluded that this system would probably be categorized as a product and strict liabilty would apply as there is no intervention by the clinician. This strict liability is also likely to apply to any evaluation which did not include continuous monitoring of the patient by trained clinicians. The owner would sue the manufacturer if an injury occurred as a result of using the system. The manufacturer would need to include this possibility when calculating the cost of the system. However, it is possible that the court will also recognise that an otherwise safe system could be misused by the physician or patient who purchases it.

13.3 Evaluation of Clinical Decision Support Systems

It was ruled earlier that the evaluation of medical expert systems is likely to follow closely the approach adopted in the testing of new drugs. Clinical trials of new drugs involve four stages. Stage 1 is the initial evaluation using a few healthy patients in order to assess tolerance and toxicity of the drug. Stage 2 evaluates efficacy, that is, dose response. Stage 3 compares the new treatment with existing ones. Finally, stage 4 is the long term evaluation involving possible side effects and rare events when using the new drug (Pocock, 1984).

Speigelhalter (1983) has identified four similar stages of evaluation of clinical decision aids within the systems development. Phase 1 involves performing initial testing for safety in the accuracy of advice. Phase 2 compares human and decision aid on selected subjects. Phase 3 is the controlled trial in a clinical setting evaluating and assessing the benefit to health care. Finally, phase 4 involves the longer term monitoring of routine use of the decision aid. These guidelines have been derived for medical decision support systems specifically designed for use by the clinician in a hospital environment.

Phase 1 and 2 require intervention by a clinician and are carried out in a controlled setting. Clearly, phase 3 requires a research study involving more than one centre and would therefore be a costly long term study obviously beyond the scope of the present work. The final long term trials have recieved little attention in the literature (Spiegelhalter,1983). This is probably due to the fact that apart from the system to diagnose acute abdominal pain sited at Leeds (De Dombal, 1983, De Dombal et al 1986) there are few medical advisor systems in operation that have reached this stage of implementation (Adams et al, 1981).

The main obstacle when planning the evaluation of this system is the fact that the system is to be based in the home. The legal liability problems are that strict product liability will probably apply in the event of detrimental healthcare as a result of using the system. Ethically, it would be unacceptable to allow the system to be used unchecked in the diabetic's home and it would be analagous to introducing a new drug without first testing the drug for efficacy. Therefore, when considering the ethical and legal liability issues, the evaluation of the Diabetic

Management System should only be carried out in the home with continuous intervention of a diabetic specialist. This option is clearly beyond the scope of this research thesis.

It is therefore necessary to devise a method of evaluation for this system that is ethically and legally acceptable but allows the assessment of the system from the user's viewpoint. The system must be evaluated for its data capture and interface facilities in addition to the advice facilities. Some parts of the system i.e. data capture facilities , could be used in the patient's home without medical intervention because it provides the same facility as the diabetic record book, offering no advice at all. The advice facilities of the system could only be evaluated by demonstrations to diabetic children and their family in a hospital setting. This method would allow some initial user feedback on the advice facilities without risking legal liability and unethical practices. The following section describes the methods employed to perform an initial evaluation of this system.

13.4 Evaluation of a Micro Based Advisor for the Management of Juvenile Diabetes Mellitus.

To perform an initial evaluation it was necessary to consider the methods and resources that could be realistically employed and would not risk detrimental legal liability or ethical issues.

The resources available included a limited number of Olivetti M24 (twin disk drive) machines that could be loaned to volunteer diabetic patients to be used in their homes. Dr. Peter Swift, Consultant Paediatrician at Leicester General Hospital also agreed to the system demonstrations taking place in the waiting room of the outpatients clinic.

The Diabetic Management System may be considered as comprising of two main sub-systems :-

(i) Data capture facilities for blood glucose results and other diabetic information

(ii) An advisor facility to aid in the control of Juvenile Diabetes Mellitus

It has already been noted that the advisors' facility cannot be evaluated unchecked within the diabetic's home. Evaluation of the data capture facilities does not pose the same legal and ethical difficulties. The following four tasks were identified as forming the basis of the evaluation and satisfying legal and ethical requirements :-

(i) Home based evaluation of the data capture and interface facilities

(ii) Evaluation at the diabetic clinic of the data capture and interface facilities

(iii) Patient based evaluation at the diabetic clinic of advice facilities

(iv) Clinician based evaluation of advice facilities

Table 10 overleaf gives the target and actual volunteers who completed each part of the evaluation.

The evaluation of data capture and interface facilities were relatively straightforward from an ethical and legal viewpoint because no advice was offered to the patients. The home based evaluation of the data capture and interface facilities involved the volunteer families borrowing a computer and recording diabetic data that is normally recorded in the diabetic record book. They were provided with a copy of the Diabetic Management System but only data capture facilities were available.

At the end of the four week period the system was collected and the family was asked to complete a questionnaire (see Appendix XI). In order to assess the interface of the data capture facilities of the system both the recorded data and questionnaire were examined. The completion of this task allowed an assessment of the acceptabilty of the system's data capture facilities and an indication of the amendments necessary to improve the system.

The clinic based evaluation of data capture and interface facilities included a short demonstration of the input blood test result and advice option. The participants were then asked to complete a questionnaire on the demonstration. The questionnaire requested personal details about the patient and presented some brief questions about diabetic management. Finally, positive and negative statements about the system and the demonstration were listed for the participant to indicate the extent to which they agreed (see Appendix XII). This method allowed the gathering of user feedback on both the blood test input and advice interface facilities in addition to feedback on the acceptablity of the system.

TABLE 10 Target Volunteer Diabetic Families and the Actual Number Involved

TASK	TARGET VOLUNTEERS	ACTUAL VOLUNTEERS
(i) Home based evaluation of Data Capture and Interface Facilities	6	6
(ii) Clinic Based Evaluation of Data Capture and Interface Facilities	20	15 (20 demonstrations)
(iii) Patient Based Evaluation at Diabetic Clinic of Advice Facilities	10	13
(iv) Clinician's Evaluation of Advice Facilities	6	6 (23 problems)

The patient based evaluation at the diabetic clinic involved volunteer patients participating in controlled experiments where diabetic problems were presented to the participants. The responses were noted and the problems were then entered into the system by the patients and the advice generated by the system examined. This task allowed an insight to diabetics' and their families' ability to solve diabetic problems. In addition it allowed an assessment of the system's problem solving capabilities compared to the families' problem solving capabilities.

The clinician's evaluation involved acquiring a number of diabetic diaries. The diaries were examined for problems such as hypos or high test results and the action if any was noted. The clinician was then presented with the problems and asked to explain the necessary treatment. In addition the problems were presented to the system. Both the advice from the clinician and the system were compared with the action noted in the diabetic diary.

Overall, these methods provided a preliminary evaluation allowing the assessment of user acceptability. In addition, it was possible to identify areas of the system that should be improved. The problem solving capabilities of the system were compared with both the diabetic and clinician. Finally, conclusions were drawn on both the positive and negative aspects of the system. Sections 13.4.1 to 13.4.4 include a description of each of the tasks and the feedback obtained. In order to perform tasks (i) to (iii) the following questionnaires were designed.

Evaluation Questionnaires

This section has described the tasks to be utilised in performing an ethically and legally acceptable evaluation. In order to gather the necessary feedback from the particpants three questionnaires were designed for use in the first three tasks. All three questionnaires had some common sections as participants personal details were required in all three tasks. The function of each questionnaire can be summarised as follows :

(i) Home based evaluation of the data capture and interface facilities

- to gather personal details on participants i.e. parents occupation and computer experience
- to obtain user feedback on the data capture and interface

facilities
- to obtain user feedback on the acceptability of the system

(ii) Evaluation at the diabetic clinic of the data capture and interface facilities

- to gather personal details
- to assess, by presenting diabetic problems, the educational aspect of the system
- to obtain user feedback on the data capture and interface facilities
- to obtain user feedback on the acceptability of the system

(iii) Patient based evaluation of advice facilities

- to gather personal details
- to assess problem solving capabilities of participants
- to compare problem solving capabilities of participants with that of the system

There were several questionnaire design issues to be considered for this work :

- the respondents would not have a great deal of time to complete the questionnaire. Therefore the use of multiple choice and Likert scales would minimise the amount of writing required

- some respondents may wish to make further comments and space should be designated for this option

- specialist questions on the user interface would not be suitable to ask the novice user. Therefore basic general questions would be required.

- when questioning the acceptability of such a system it was necessary to present statements on different levels. For example, the system may only be acceptable if there were certain advantages

There are many guidelines for the design of questionnaires and are well documented (Bailey, 1982). Good questionnaire design should include clear unambiguous questions. The text should use words that the respondent is familiar with. Adequate space should be left for replies. Multiple choice questions should have options for all possible replies.

The questionnaires used several design techniques. The questions presented were of both a closed and open nature. Collection of personal details involved a set of straightforward open questions. Information on computer experience was collected by multiple choice questions.

The most difficult part of the questionnaire design for tasks (i) and (ii) was devising a method of gathering some user feedback. Many of the respondents were not familiar with computers and therefore it was not appropriate to ask direct questions on the user interface. The questionnaires took the form of presenting positive and negative statements based on the user interface. The user then indicated on a Likert scale (Sharratt, 1989) whether they agreed or disagreed with the statement. This method offers the advantage of gathering specific participant reaction. Some of the statements were of a subjective nature but could be checked against the practical use of the system.

The questionnaire designed for task (iii) used open questions only. The first part of the questionnaire gathered personal, background and diabetic details, similar to that of questionnaires (i) and (ii). The second part of the questionnaire presented six different diabetic problems that the participants were asked to solve. Open questions rather than multiple choice were necessary because specific replies were very important and could vary according to the type of insulin regime the patients were following. In addition a multiple choice type of question would have provided a prompt for the correct answer. It was important to gather information on the way the individual would solve the diabetic problems. The questionnaires are presented in Appendix XI, XII, XIII.

13.4.1 Task (i) - Home Based Evaluation of the Data Capture and Interface Facilities.

This task was performed to assess how acceptable it was for the diabetic and/or their family to record diabetic data on a regular basis using the Diabetic Management System. In addition, it was hoped that user feedback would provide useful comments on the ways in which the system's interface could be improved.

The system was installed in selected patients homes for a period of one month and used in parallel with the diabetic diary. The diabetic diaries and data collected were compared. In addition, a log file holding the number of times each option was accessed was examined. At the end of the month each family was given a questionnaire to complete and full details of the completed questionnaires are included in Appendix XI.

Six patients were involved in this task. The patients volunteered at the diabetic clinic where they were introduced to the system and had the procedures explained to them. The system was delivered to the patients home, where a full demonstration took place. At the end of the month the system was collected.

A practical problem with the installation of this system was time. Several of the parents worked shifts and combined with school activities there was a significant time delay between contacting the family and installation of the computer. Another problem was the difficulty of demonstrating the system to a family after a busy day when the evening meal was being prepared/cleared with younger members of the family requiring attention. All the families involved were given a telephone number to contact in case of difficulties. In addition each family was contacted a few days after installation to ensure that any problems were reported.

The participants completed a questionnaire at the end of the four week period. The first part of the questionnaire collected personal, background and diabetic information. The second part of the questionnaire was divided into three sections. Each section collected user feedback on entering blood tests, entering any other data and the overall system. This was done by presenting both positive and negative statements about the interface facilities and system acceptability. In addition space was given under each section for futher comments.

13.4.1.1 Home Based Evaluation Report

A sample of the questionnaire with the volunteers replies follows the case reports (Table 13). At the end of this section there is a short discussion summarising the home based evaluation. Table 11 gives a brief overview of the volunteer families. The results of the home based evaluation are given in the form of individual Case Studies. The raw set of results from this work is documented in Appendix XI.

TABLE 11 USER INTERFACE HOME TRIALS : CASE STUDIES

CASE STUDY 1	Parents Occupations :	Mother - Occupational Therapist Father - Biochemist		
Predominant User	Diabetic's age	Term	Sex	
Father	10 years	1 year	female	
CASE STUDY 2	Parents Occupations :	Mother - Student Father - Deceased		
Predominant User	Diabetic's age	Term	Sex	
Mother	8 years	7 years	female	
CASE STUDY 3	Parents Occupations :	Mother - Local Government Clerk Father - Systems Manager		
Predominant User	Diabetic's age	Term	Sex	
Father	11 years	1 year	male	
CASE STUDY 4	Parents Occupations :	Mother - Company Director Father - Company Director		
Predominant User	Child's age	Term	Sex	
Diabetic	16 years	12 years	male	
CASE STUDY 5	Parents Occupations :	Mother - Nursery Nurse Father - Builder		
Predominant User	Child's age	Term	Sex	
Diabetic	13 years	9 years	female	
CASE STUDY 6	Parents Occupations :	Mother - Post Office Clerk Father - Assistant Computer Shift Controller		
Predominant User	Child's age	Term	Sex	
Father	14 years	1 year	female	

USER INTERFACE HOME TRIALS : CASE STUDIES

Case Study 1

The family included the diabetic, a female of age 10 years, who was diagnosed approximately 1 year ago. Her mother was an occupational therapist and her father, a biochemist, was the predominant system user entering the data at the end of the day. The diabetic child usually writes the results of blood tests in the record book throughout the day.

One week after installation the family asked for some help on recording the blood tests. The problem being that there was some uncertainty as to when and how the date should be changed to ensure the recording of blood tests. Most of the data recorded were blood test results but the user had entered all other options at least once but no more than 3 times. The general comments made were that after initial problems i.e. unsure how to control the system date , there were no further problems with recording data.

However, the user pointed out that the system recorded BM test strip results only whereas they used Exacted strips. Unfortunately, this was not mentioned at any time during the systems use when they would have been provided with the appropriate software. However, it is a minor task to convert the Exacted strip result to a BM test result. The user concluded that the system was easy to use but additional general information for diabetic children would have been helpful.

Case Study 2

The family included the diabetic, a female of 8 years who had been diagnosed before the age of 1 year. Her father was deceased and her mother was a computing student who was the predominant system user, entering information at the end of the day. The mother normally recorded the blood test results in the record book at the end of the day.

There was little evidence of recorded information under any section. This was due to the date not being changed every day.

The user concluded that it would help if the system provided information on carbohydrate exchange.

Case Study 3

The family included the diabetic, a male of 11 years who had been diagnosed for over 1 year. His was mother a local government clerk and his father was a busy systems manager who was the predominant systems user. Usually the test results were written in the record book through the day by both parents. The father entered the blood test results at the end of the week.

The main complaint was that the system was time consuming because of the large amount of data being input at the end of the week. This method was adopted because the father was busy all week having no time to enter the results on a daily basis. Further comments were that the system was slow and physically cumbersome when compared to the computer technology the user was familiar with.

The user concluded by stating that the basic idea was good if it could be extended to provide advice/guidance based on history.

Case Study 4

The family included the diabetic, a male of 16 years who had been diagnosed at the age of 4 years. His parents were directors of the family business. The diabetic was the sole user of the system entering the data at the end of the day. Usually the blood test results were written through the day in the record book by the diabetic.

All sections of the data input, except stress, were used several times, particularly the free format comments section. The diabetic had no problems using the system other than minor keyboard problems.

The user would have preferred to exit from any point in the system. He stated that the system would be very useful to the newly diagnosed diabetic.

Case Study 5

The family included the diabetic, a female aged 13 years who had been diagnosed at the age of 4 years. Her father was a builder and her mother a nursery nurse. The diabetic was the sole user of the system entering information throughout the day. Usually the information was written in the record book throughout the day by the diabetic.

The blood tests had been entered for every day that the diabetic had the system. Several other options had been used particlarly the free format comments section.

The user had no problems with using the system. She concluded by stating that she found it useful and enjoyed using it. Her mother added that her daughter took over the system completely independently and she enjoyed using it but wondered if the novelty would have worn off given time.

Case Study 6

The family included the diabetic, a female aged 14 years who had been dignosed approximately 18 months ago. Her mother was a post office clerk and her father was an assistant computer shift controller who was the sole user of the system. Usually the test results were written in the record book 'weekly or when a blood test is done' by the diabetic. The father entered the blood test results every 2 - 3 days.

Blood test results were recorded but not regularly. During discussions with the father at the time of installation it became apparent that blood tests were taken infrequently (once or twice every few days rather than regularly every day) and his daughter found the regime of carbohydrate control difficult to follow. In addition the times and quantity of insulin taken varied frequently. Apart from blood test results no other information had been recorded.

The user mentioned that he found it slightly difficult to record blood test results. The general comment was that although it had been an interesting exercise, the system tended to 'make a drama out of a crisis' for a reasonably controlled diabetic. It was added that the system may be of considerable help to someone with blood sugar control difficulties!

TABLE 12 Use of Data Capture Facilities by Each Participant

Frequency of Use	Data Capture Facilities					
	Blood Tests	Insulin	Carbohydrate	Hypos	Exercise	Others
Frequently	1 3 5 4					
Sometimes	6 2	1 4 5	1 4 5	1 4 5	1 4 5	1 4 5
Never		2 3 6	2 3 6	2 3 6	2 3 6	2 3 6

Table 12 indicates the frequency that each of the data capture facilities was used by the participants. The two teenage participants (4,5) who used the system independently and the biochemist (1) whose daughter had been diagnosed for one year utilised the data capture facilities most . In addition participant 3, the systems manager entered blood tests regularly and participant 6, the computer shift controller entered as many blood tests as were taken.

The use of some of the data input options are difficult to assess in one month because it is not unusual for example, for carbohydrate allowance to remain the same for four weeks. However, the teenagers and biochemist used all the data capture facilities. The information recorded in the diabetic record book for this period was very similar to the data recorded on the system's files.

TABLE 13 Home Based Evaluation : Volunteer Questionnaire

Summary table giving the frequency of responses from the 6 case studies. Identification of participants given in brackets.

	Disagree	Neither Agree or Disagree	Agree
I would record insulin, carbohydrate and hypos regularly if I had a system like this.	3 (3 4 6)	0	3 (1 2 5)
The system would be more useful if it could provide general advice and information about diabetes.	0	0	6
If the system could offer advice (e.g. adjust insulin level) based on the recorded data it would be more useful.	0	0	6
If the system could offer advice I would prefer to ask the Doctor or Health Visitor for advice.	1 (4)	3 (3 5 6)	2 (1 2)

13.4.1.2 Home Based Evaluation - Summary

Overall, reaction to the system was mixed and is illustrated by the responses in Table 13. A general complaint was that it was time consuming to record blood test results. All volunteers would have preferred advice and information about diabetes in addition to data capture facilities. There was a mixed reaction to whether the volunteers would prefer to ask the doctor/health visitor for advice.

Some of the practical problems involved included some patients forgetting to correct the system date. This resulted in some data being lost. A minor amendment to the system would be a warning to check the system date. Several users would have preferred to escape from the system at any time including the recording of blood tests. This facility could be included with the minimum of amendments to the program code.

The most positive feedback concerning the system came from the teenage volunteers who used the system independently. In addition positive feedback was gained from the biochemist who had little computing experience. The general opinion from the other participants being that recording blood tests might have been worth the effort if the system offered advice based on the test results and general information on diabetes. This is an interesting point as this part of the evaluation may have resulted in more positive feedback had it been ethically and legally possible to have included the advice facilities in the home based evaluation.

13.4.2 Task (ii) - Evaluation at Diabetic Clinic of the Data Capture and Interface Facilities

This task was completed in order to assess user acceptability of both the data capture and advice interface facilities. Further user feedback in the form of comments were gathered from all participants.

The demonstrations took place at the diabetic clinic in a small room just off the waiting room. There were several practical problems encountered during this task. Most of the parents had been waiting some time before seeing the specialist, several had young children and most families were reluctant to spend extra minutes at a demonstration and completing a questionnaire. The only way this situation could be helped was by offering the family an S.A.E. to return the questionnaires that would be completed at home. The Evaluation Proposal (see Appendix X) set a target of 20 demonstrations at the diabetic clinic, 8 questionnaires were completed at the clinic and 7 questionnaires were returned by post. Thus, out of 20 completed demonstrations, a total of 15 completed questionnaires were returned, giving a 75% response rate.

The questionnaire was designed in order to gather information on several aspects :

1. Personal details of the diabetic were requested.

The details included age and term of the diabetic, giving an indication of how familiar the participants were with diabetic problem solving. Information on computer experience and whether they had a home computer was asked in order to assess computer familiarity.

2. Diabetic problem solving skills were assessed.

A diabetic problem was presented on the first page of the questionnaire. The problem was either :

Persistent high pre-breakfast blood tests

or

Persistent hypos occurring mid morning

In addition to asking the diabetic the action he/she would take in order to solve the problem they were asked to specify the checks or questions that they would ask before taking the action. Another diabetic problem was presented on the second page. This was completed after the demonstration and the response was used to assess whether the method of problem solving had changed after the demonstration.

3. Assessment of the user acceptability of the system.

Positive and negative statements were presented to the user on both the input blood test section and advice facilities. In addition similar statements were presented on general aspects of the system. Although the demonstration was limited it was necessary to assess whether the participants found the systems instructions easy to understand and whether they would find the system useful at home. Finally space was left for the participants to add any comments.

The details of the demonstration were as follows :

A short explanation on the background of the system was given and how it might help advise diabetic children and their families.

Before the demonstration started the participants were asked to complete the first page of the questionnaire. This requested personal details and a common diabetic problem was presented to the participants asking them how they might solve it.

The participants were shown how to input a blood test and they were invited to input another test. The time taken by the participant to enter a blood test was recorded.

The participants were then shown the advice facilities. A common diabetic problem was used to illustrate the problem solving capabilities of the system. The participants were then invited to try out the advice facilities for themselves.

At the end of the demonstration, participants were requested to complete the questionnaire. The rest of the questionnaire included a further diabetic problem in addition to positive and negative statements about the system whereby the participants had to indicate the extent to which they agreed with the statements.

The following pages give a brief overview of the personal details of the participants and the results of the questionnaire. An overview of the results of the clinic demonstration is also given.

13.4.2.1. Clinic Demonstrations Report

Participants Review

The fifteen diabetic participants consisted of 7 females and 8 males with ages ranging from 6 years to 16 years. Their term of diabetes ranged from several months to a maximum of 12 years. All the children had computer experience and several had a home computer. The occupation of the parents included housewives, nurses, builders and company directors. The majority had some computer experience. Full details of the completed questionnaires can be found in Appendix XII, a summary of participants is given in table 14.

TABLE 14 Clinic Demonstration : Participant Summary

Parents occupations		Childs	Age at	
Father	Mother	Age	Diagnosis	Sex
1. British Telecom Engineer	Caterer	11	8	m
2. Not Stated	Not Stated	10	6	m
3. Not Stated	Housewife	12	7	f
4. Not Stated	Not Stated	13	13	m
5. Pharmacist	Nurse	10	9	f
6. Director	Director	16	4	m
7. Not Stated	Housewife	12	11	m
8. Builder	Shop Assistant	6	5	m
9. Not Stated	Designer	7	2	m
10.Biochemist	Occupational Therapist	9	9	f
11.Builder	Nursery Nurse	13	4	f
12.Comp. Shift Controller	Post Office Clerk	14	13	f
13.Solicitor	H.E. Student	15	5	m
14.Deceased	H.E. Student	8	<1	f
15.Sub-Contracts Controller	Building Society Manager	11	10	f

Diabetic Problem Solving

The diabetic problem presented before the demonstration was answered correctly by the majority of participants. However the answers were general and many chose to adjust insulin without considering other possiblities. The diabetic problem presented after the demonstration was answered correctly by the majority of participants. Three participants answered the first problem incorrectly and two answered the second question incorrectly. One respondent answered both questions incorrectly. This information is presented in Appendix XII.

Questions on the Demonstration

The respondents replies are summarised in Table 15. When asked what problem the demonstration gave advice on , fourteen answered correctly stating that the problem was either hypos mid morning or early morning. The Diabetic Management System asks the user about exercise, carbohydrate etc. before giving advice. When the participants were asked to write down the questions the system asked before offering advice eleven respondents remembered between two and four questions correctly. From an educational aspect this result is very promising. In order to perform decision making on insulin adjustment it is necessary to check that the diabetic problem is not due to other factors e.g. exercise. The system may offer an educational benefit by systematically taking the user through the checks necessary in order to allow effective decision making. The user should, after using the system, be able to work through the checks independently.

TABLE 15 Summary of Questions on Demonstration

Question :	What problem did the system give advice on ?
Correct Answers From Participants	1 2 3 4 5 6 7 8 9 10 11 12 13 15
Incorrect Answers From Participants	14

Question : What questions did the system ask before giving advice ?															
Participant Number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Number of Questions Remembered	4	3	0	3	3	4	3	0	4	4	2	0	3	0	2

User Participation

Three of the fifteen participants declined to try out the data capture and advice facilities for themselves giving the reason that they did not have the time. However all other participants who attempted to input a blood test did so successfully and took approximately 45 seconds from starting and returning to the main menu. Those participants who tried out the advice section took under one minute to obtain advice (see Table 16) on a particular diabetic problem. Most of the questions asked at this time were about the position of a key rather than what should be entered.

TABLE 16 Summary of Time Taken (seconds) for User Participation

Participant Number	1	2	3	6	7	8	9	10	11	12	13	15
Entering Blood Test	45	40	47	41	50	46	43	51	46	43	39	44
Obtaining Advice	50	49	55	56	45	59	59	57	51	51	52	57

TABLE 17 Participant Feedback : Entering Blood Tests

The table below indicates the frequency of respondents replies to each statement.

	Disagree	Neither Agree or Disagree	Agree
*The information and instructions were easy to understand.	2	2	10
I would have preferred more information and instructions.	9	6	0
It was easy to enter blood tests.	2	1	12
This part of the system would be useful at home.	3	3	9
I would prefer to record blood tests in the record book.	4	4	7

* One participant did not respond to this statement.

Table 17 above provides a summary of user feedback on entering blood tests and the reaction was somewhat mixed. In brief, most of the participants found the information and instructions easy to understand and would not have preferred more instructions. Sixty percent of the respondents said that they would find this part of the system useful at home. Approximately forty-six percent stated that they would prefer to record the information in the diabetic record book.

A correlation between parents occupations and user feedback on entering blood tests was not evident. In addition there was no correlation between user feedback and those newly diagnosed diabetics as illustrated in Table 18.

One of the participants commented that it would be useful if the system was set up in the patient's room. Two parents thought that their children would be encouraged to record their blood tests if they had a system.

TABLE 18 Individual Participant Replies : Entering Blood Tests

	Do Not Agree	Agree
This part of the system would be useful at home.	1 2 7 8 9 12	3 4 5 6 10 11 13 14 15
I would prefer to record blood tests in the record book.	1 3 4 5 6 11 13 14	2 7 8 9 10 12 15

Table 19 (overleaf) summarises the user feedback on the advice facilities and again the reaction was mixed. Sixty-six percent of the respondents agreed that the information and instructions for this part of the system were easy to understand and they did not want further information. In addition the majority found the questions and advice clear. There was a mixed reaction to the usefulness of this part of the system. There was no observable link between parents occupations and user reaction. The user feedback of the newly diagnosed was similar to that of the longer term diabetic. One of the participants commented that as his son had only been recently diagnosed "it very quickly brought to mind the information needed to sort out the problem" and they found it helpful because they were "not geared up to what questions to ask ourselves straight away". Another participant aged sixteen and had been diagnosed at four commented that the system would be useful if it could point out problems.

TABLE 19 Participant Feedback : Advice Facilities

The table below indicates the frequency of participant response to the statements presented in the questionnaire.

	Disagree	Neither Agree or Disagree	Agree
The information and instructions were easy to understand.	1	4	10
I would have preferred more information and instructions	9	4	2
The questions were easy to understand and answer.	1	2	12
The advice was clear and easy to understand.	1	2	12
This part of the system would be useful at home.	4	3	8
The computer could provide advice on problems that I would have difficulty solving on my own.	7	4	4
The problems that the computer could help me with are straightforward.	0	3	12
The computer could help me solve some problems.	3	3	9

TABLE 20 Participant Feedback : Overall Comments

The table below indicates the frequency of respondents replies.

	Disagree	Neither Agree or Disagree	Agree
Overall, I would like a computer system like this.	3	5	7
*I would only want a system like this if it would definitely improve my (or my child's) blood sugar control.	2	4	8
I would like a system like this to help me learn more about diabetes.	3	3	9
If I had a computer like this I would be unlikely to use it.	9	3	3
I would find a computer like this time consuming.	9	1	5
I think that a computer like this would be helpful occasionally.	6	5	4

* One participant did not respond to this statement.

Table 20 presents a summary of the overall user reaction to the system. Approximately half of the participants stated that they would like a system like this at home. Another six agreed that they would want a system if it would improve the child's blood sugar control or provide an educational benefit (see Appendix XIII, page XIII-15). Only three said that if they had a system like this they would be unlikely to use it but five thought it would be time consuming. There was little correlation between length of term or parents occupations and user reaction.

13.4.2.2 Clinic Demonstration - Overview

The participants included a mix of ages and varying experience with diabetes. All the diabetics and many of the parents had some computer experience. Nine of the families had a computer at home which is an encouraging point to note as the cost of such a system would be reduced if the family already own a machine to run the software.

Out of fifteen completed questionnaires, only six participants added comments in the space provided. Overall reaction to the system at the diabetic clinic was mixed. Most participants found the system's instructions and information when entering blood tests easy to understand. This reaction was endorsed by the speed with which most participants entered a blood test (see Table 16) . A similar reaction was noted for the advice facilities. In addition many of the participants recalled correctly at least two of the questions presented within the advice facilities indicating a possible educational benefit.

Approximately half of the participants said that they would like a computer system like this. Further participants indicated that if the system offered benefits of diabetic education and an improvement in blood glucose control they too would use such a system. Finally, some of the most positive feedback came from the families of newly diagnosed patients.

13.4.3 Task (iii) - Patient Based Evaluation at the Diabetic Clinic of Advice Facilities

This task was completed to assess the patient's ability to solve diabetic problems and compare their answers with that of the Diabetic Management System. Originally this task was specified as selected patients should participate in controlled experiments involving presenting real and fictitious problems to the patients and noting the actions they would take to solve the problem. While Task (i) and Task (ii) were in progress it was apparent that most families did not want to spend more time than necessary at the diabetic clinic. Therefore a questionnaire was designed that could be completed while parents were in the waiting room or at home (see Appendix XIII) This action allowed the gathering of data that would not have been collected had the original plan been followed.

The questionnaire involved questions on two areas :

1. Personal details and diabetic regime

Personal details included parents occupation, diabetic age and term and is summarised in Table 21. In addition the diabetic's insulin regime was required in order to assess the answers to problem solving questions (full details are presented in Appendix XIII). Participants were also asked to indicate whether they adjusted insulin levels between clinics and for what reason. This information is presented in Table 22.

2. Problem solving

Six questions were presented in order to assess the diabetic and/or their parents ability to solve diabetic problems (Table 23). In addition, the identification of those who were better at problem solving than others is necessary, in order to assess who might best benefit from a system such as this. The questions were designed to test insulin adjustment ability and identification of times when other action was necessary. The six problems, although the same for each diabetic, would have a different correct answer for each diabetic depending on the regime of that particular diabetic. A summary of the answers to the diabetic problems is given in Table 24.

13.4.3.1. Patient Based Evaluation of Advice Facilities - Report

The system was set up for the regime of each diabetic. The problems were then entered and the results noted. The diabetic responses and computer advice was compared. The following pages give a summary of the paricipants personal details and the results of the problem solving questions.

TABLE 21 Summary of Participants Completing Diabetic Problem Solving Questionnaire

The table below indicates the parents occupations and the diabetic's sex, age and age at diagnosis . Two questionnaires were returned with incomplete information (respondents 8 and 12).

	Parents occupations			Age At	
	Father	Mother	Age	Diagnosis	Sex
1.	Systems Manager	Local Government	11	10	m
2.	Deceased	Student	8	11 mths	f
3.	Director	Director	16	3.5 yrs	m
4.	Fitter/wireman	Shop assistant	5	2	f
5.	Warehouse Manager	Accounts clerk	14	12	f
6.	Managing Director	Housewife	17	4	m
7.	Travel Agent	Housewife	4	4	f
8.	Not Stated	Not Stated	11	9	f
9.	Computer shift controller	Post Office assistant	13	13	f
10.	Production Controller	Housewife	6	5	f
11.	Painter & Decorator	Cashier	12	4	f
12.	Not Stated	Not Stated	17	2	f
13.	Biochemist	Occupational Therapist	10	9	f

TABLE 22 Summary of Respondents' Insulin Changes Between Clinic Visits

The table below shows the details of insulin adjustment between clinic visits for the 13 respondents. The first column indicates whether adjustments are made between clinics. The central column specifies the reasons stated for altering insulin levels. The third column indicates the person who makes the decision to alter insulin.

Rt* No.	Adjustment	Reason	Who makes the decision
1.	No	High blood tests	Doctor
2.	Yes	High blood tests, Illness	Mother
3.	Yes	High blood tests	Diabetic
4.	Sometimes	High blood tests,Hypoglycaemia	Parent/Doctor
5.	Yes	High blood tests, Hypoglycaemia, Activities	Mother
6.	Yes	High blood tests, Hypoglycaemia	Mother/Doctor
7.	Only once	Erratic blood tests, Hypoglycaemia	Doctor
8.	Sometimes	High blood tests, Hypoglycaemia	Mother
9.	Yes	Hypoglycaemia	Parents
10.	Yes	Blood test results	Mother
11.	Yes	High blood tests, Hypoglycaemia	Mother
12.	Yes	Weight control	Diabetic
13.	Sometimes	Not stated	Parents

* Respondent number

TABLE 23 Summary of Diabetic Problems Presented in the Questionnaire

Problem ID	Problem Type
A	Hypos occurring in the early hours of the morning.
B	High blood test results occurring in the morning.
C	A hypo occurring after a sports lesson.
D	Hypos occurring just before the mid-morning snack is eaten.
E	High blood test results occurring in the evening.
F	High blood test results occurring when the diabetic also has flu'.

TABLE 24 Diabetic Problem Solving Results

The table below presents a summary of the respondents attempts to solve the above diabetic problems. The answers could be divided into six categories. For each problem presented, the frequency of answers is displayed. N/A indicates that the solution listed in the answers column was not applicable.

Answers	Problem					
	A	B	C	D	E	F
Do not know	2	2	1	1	2	2
Ask Doctor	1	1	0	1	2	2
Correct Immediate Solution	4	N/A	8	2	N/A	3
Correct Long Term Solution	1	2	3	4	1	N/A
Correct but Incomplete	5	8	1	5	7	5
Incorrect Solution	0	0	0	0	1	1

General observations

Out of the 13 respondents, 5 were newly diagnosed and 5 had been diagnosed for more than seven years. Several interesting observations were made on examination of the responses. Overall, the least successful replies came from the newly diagnosed. Two of the newly diagnosed families did not adjust insulin levels between clinic visits, their occupations included a travel agent and systems manager. One of the answers provided by the parents of a newly diagnosed diabetic was incorrect (see Table 21, participant 13).

The possibility of a correlation between types of occupation and the ability to solve diabetic problems was considered. However, there was no observable difference in ability between those manual workers and those in management posts.

The most successful replies came from families where the diabetic had been diagnosed for at least seven years (participants 2, 3, 6, 11, 12). Four of the patients had insulin treatment of 4 injections per day using two types of insulin, indicating that the clinician considered them capable of coping with a more complicated treatment. Participant 11 (occupations were a painter/decorator and cashier) was on a simpler form of treatment i.e. two injections using one insulin per day. Although a long term diabetic, one of participant 11's answers was incorrect. The most successful and comprehensive reply was that of participant 6, a diabetic for 13 years.

Many of the replies were partially correct but it was clear that the patients did not follow a process of elimination when deciding what course of action should be taken. Most patients, when noting that the problem was hypoglycaemia, either attempted to prevent the short term symptoms or opted for decreasing the insulin dose preceding the attacks. Few patients checked carbohydrate intake and exercise preceding the hypos. This is reinforced with Problem D which presented a problem of attacks of hypoglycaemia just before the morning snack. An obvious solution would be to eat the snack earlier but six patients opted to adjust the insulin dose. However when Problem C indicated the hypo was linked to the sports lesson most patients opted for the correct solution by eating extra carbohydrate.

Similarly, high blood test results were treated with an increase in insulin without checking for the possibility of extra carbohydrate as a cause. Few patients, when opting for adjusting insulin, mentioned that it is necessary to follow up any action taken by checking the blood test results following the adjustment.

13.4.3.2. Patient Based Evaluation of Advice Facilities : Conclusions

Overall, each diabetic problem produced replies indicating that several patients could not solve the problem and many respondents did not follow procedures for successful decision making. The newly diagnosed participants were least successful at problem solving while the problem solving capabilities of those patients diagnosed for many years and were following a more complicated insulin regime provided the best solutions. There was little correlation between parents occupations and the ability to problem solve.

Few respondents checked all possibilities before adjusting insulin and few followed up their actions by monitoring the proceeding blood tests. The Diabetic Management System, when attempting to solve diabetic problems always checks the possibility of carbohydrate and exercise before advising on the adjustment of insulin as a solution. In addition it monitors the following blood tests checking for associated follow up problems. The preceding checks are necessary in order to ensure that insulin is not adjusted unecessarily causing further blood glucose control problems. These checks are necessary to confirm the correct action or to pinpoint blood glucose problems associated with the insulin adjustment.

The system provided correct and comprehensive solutions to each of the diabetic problems. It may be concluded that the system could offer a positive benefit to the newly diagnosed patients for whom it is most needed. In addition patients that have been diagnosed for some time would also benefit from the reinforcement of the checks that are required in order to provide effective blood glucose control.

13.4.4 Task (iv) - Clinician Based Evaluation of Advice Facilities

This task involved the collection of diabetic diaries or record books. These were examined and diabetic problems were highlighted. Some situations that were just below the system's problem solving threshold were also identified. The clinician was then asked to comment on the action necessary to treat the problem. The blood test results and other recorded data was then entered into the system and recommended advice given by the Diabetic Management System was compared with the clinician's advice and action as noted in the record book .

Although 12 diaries were collected only 6 were suitable to be used for this work. The main problem being the lack of information documented in the diaries and the delay in obtaining new diaries. Most patients take the current diary with them to the diabetic clinic. This resulted in a one month wait until the next clinic in order to collect completed diaries. Many diaries did not have a comprehensive record of data. Some had sections with no blood tests recorded. Many did not have any supplementary notes or comments. Several had questionable 'perfect' blood test results with no problems associated with them.

Six record books provided plenty of material to complete the work but the diaries did not report sufficiently on occurrences of hypoglycaemia. This may be due to the fact that patients suffering the initial symptoms of a hypo take a glucose tablet or sweets. This action prevents the symptoms becoming worse and the patient very often recovers quickly. Many patients do not record this event and it is impossible to forecast the severity of the hypo if it were left untreated once glucose has been administered. Table 25 summarises the problems presented in the six record books.

TABLE 25 Record Book Number and Associated Problems

Record book number	Number of problems	Types of problems
1	7	high tests, flu
2	2	high tests
3	6	hypos,high tests
4	1	high tests, flu
5	4	high tests
6	3	high tests

Note: Record book 5 and 6 were that of newly diagnosed diabetics

Most of the problems identified were high blood test results. These were marked on the photocopied diaries and each problem was assigned an identifying number. The clinician was given a copy of the diary and the advice he gave on each problem was noted. A general comment that has been mentioned several times by the clinician is that although treatment and advice at the diabetic clinic is based on the information presented in the record book it is also essential to discuss problems with the patient. It is not unusual for the clinician to identify a problem that has not been entered in the diary by 'casual discussion'. In addition it was noted that there is a certain reluctance for patients to update their diaries with supplementary comments.

13.4.4.1 Clinician Based Evaluation - Report

The following pages report on the outcome of this work, starting with Record Book 1, (see Table 26). The full results are documented in Appendix XIV. Finally a general discussion on the accuracy and usefulness of the systems advice is given.

TABLE 26 Summary of Diabetic Problem Solving by Patient, Clinician and Diabetic Management System

PATIENT 1

Problem Number	Problem Type	Action Taken By Patient	Clinician's Advice	System's Advice
1	High tests + flu	Extra Test	More tests	More tests
2	High tests	Inc. am ins.	More tests	More tests
3	High tests	Inc. ins.	Inc. ins.	Inc. ins.
4	High tests	Inc. am ins.	More tests	Inc. am ins.
5	High tests	None	More tests	More tests
6	High tests	None	More tests	More tests
7	High tests	None	More tests	More tests

PATIENT 2

Problem Number	Problem Type	Action Taken By Patient	Clinician's Advice	System's Advice
1	High tests	Inc. pm ins.	Inc. am ins.	Inc. am ins.
2	High tests	Inc. pm ins.	Inc. am ins.	Inc. am ins.

PATIENT 3

Problem Number	Problem Type	Action Taken By Patient	Clinician's Advice	System's Advice
1 & 2	High tests/hypos	Various	Warning	Warning
3 to 6	High tests/hypos	Various	Warning	Warning

TABLE 26 Continued

PATIENT 4

Problem Number	Problem Type	Action Taken By Patient	Clinician's Advice	System's Advice
1	High tests + flu	Inc am long	Inc am long	Inc am long

PATIENT 5 - Newly diagnosed

Problem Number	Problem Type	Action Taken By Patient	Clinician's Advice	System's Advice
1	High tests	None	None	None
2	High tests	Inc. am ins.	Inc am ins.	Inc. am ins.
3	High tests	Inc. am ins.	Inc am ins.	Inc. am ins.
4	High tests	Inc. am ins.	Inc am ins.	Inc. am ins.

PATIENT 6 - Newly Diagnosed

Problem Number	Problem Type	Action Taken By Patient	Clinician's Advice	System's Advice
1	High tests	Inc. am ins.	Inc. am ins.	Inc. am ins.
2	High tests	None	More tests	More tests
3	High tests	Inc. pm ins.	Inc. pm ins.	More tests

Abreviations

Inc. : Increase
pm : evening
am : morning
ins. : insulin
long : long acting insulin

13.4.4.2. Discussion

Table 26 gives a summary of the problems presented in each diabetic diary along with the action recorded by the patient, advice recommended by the clinician and the associated system's advice. The advice provided by the system was very similar to the clinician's advice. Slight differences between the two occurred for Patient 1, Problem 4 and Patient 6, Problem 3 (see Table 26). The clinician chose to wait for more tests for Patient 1, while the system advised an increase of insulin. For Patient 6, the clinician advised an increase of insulin, whereas the system advised the patient to take more tests. In the case of both patient problems, waiting for more tests indicates that if the next test is also high, then insulin should be increased.

Although several patient decisions were in accordance with both the clinician's advice and that of the system there are some important differences for patients 2 and 3. Patient 2 realised that it was necessary to increase insulin in order to prevent further high tests but chose the incorrect time at which to make the increase. Unfortunately this sort of error can lead to further problems, while the original high tests remain untreated.

Patient 3 illustrated an unusual problem where the patient although vigilant about blood tests was suffering many high tests and regular hypos. This problem resulted from too many insulin adjustments and the patient did not wait to see the results of one insulin change before making another. The clinician explained that this patient was cared for by another doctor and he showed concern at the number of insulin adjustments. The system issued a warning stating that there should be a period of at least 3 days between insulin adjustments. In addition, given the information the system advised the patient to contact the health visitor or doctor.

It must be noted that although the action taken by the patient was similar to that of the system's and clinician's advice, the majority of decisions were made without the patient using extra blood tests to monitor blood sugar levels afterwards (full details are reported in Appendix XIV). This would check the effect of the action taken.

13.5 Summary of Evaluation

The evaluation of the micro based decision aid has involved four tasks :

(i) Home based evaluation of the data capture and interface facilities
(ii) Evaluation at diabetic clinic of data capture and interface facilities
(iii) Patient based evaluation at the diabetic clinic of the advice facilities
(iv) Clinician based evaluation of advice facilities

The home based evaluation of the data capture and interface facilities produced a mixed reaction amongst the participants. However, the majority recorded a substantial amount of data. In addition, positive feedback was gained from three participants including the two teenage volunteers who used the system independently. The others concluded that had the system produced advice it would have been more worthwhile.

The evaluation at the diabetic clinic of the data capture and interface facilities showed that the volunteers found it relatively easy to input blood tests and use the advice facilities. Parents of newly diagnosed diabetic children reacted most positively.

The patient based evaluation of the advice facilities at the diabetic clinic involving the participants in diabetic problem solving revealed interesting information on their ability to solve diabetic problems. Many of the participants knew how to adjust the insulin levels but failed to check other possibilities beforehand. In addition they did not carry out follow up checks on blood test results.

The clinician's evaluation of the advice facilities illustrated the lack of information recorded in many record books. Both the clinician's advice and system's advice corresponded. Three of the six patients solved their problems correctly but often failed to take more tests at the time of the problem and immediately after insulin levels had been altered.

CHAPTER 14

The Home Based Diabetic Advisor : Discussion

14.1 Diabetic Control

The aim of this thesis was to identify procedures for the control of blood sugar levels in the insulin dependent juvenile diabetic and examine the role of a home based microcomputer to aid diabetic management.

Diabetes is different to many clinical control problems because the sufferer and their family have to maintain the balance of carbohydrate, exercise and insulin without the day to day supervision of the clinician. On completion of a literature survey it was concluded that although several aids were available to improve blood sugar control (see Chapter 4), such as a blood gluose meter (Smith et al, 1985) and hypoglycaemia alarm (Alric et al, 1980) they could not offer advice on diabetic management. In addition systems developed to offer advice were designed as a decision making aid for the clinician. Therefore a need was identified for a home based management aid to be used by the diabetic or parents in order to improve blood glucose control and thus reduce the risk of long term complications of diabetes.

An examination of the clinical reasoning involved in the management of diabetes resulted in a two stage process being identified (see Chapter 7). An algorithm was developed utilising the processes and it was implemented in a modular system to aid diabetic control. The approach taken in this system is unusual in that it is a system designed for the diabetic to be used in the home of the diabetic. The system is versatile and allows the clinician to amend its advice text and structure if necessary.

The need for formal evaluations of advisor systems has been noted by a number of authors (see, for example, Speigalhalter, 1983). In order to proceed with an evaluation it was necessary to consider the ethical and legal issues surrounding the use of home based medical advisor systems. The literature showed that there are many considerations associated with medical decision support systems. However, the literature revealed that although much has been written about the systems designed to be used by the clinician and some about mass produced general advice systems for the non expert (Mortimer, 1989), there is little discussion of home based systems designed for the individual. Eventually Medical Decision Support

Systems may be subject to regulatory control but it will be some time before a system such as this will have guidelines applicable to its evaluation. This system probably presents a unique situation in terms of ethical and legal problems.

Until these issues are resolved the full scale evaluation that is required cannot proceed. The evaluation that should take place in the home of the diabetic cannot ethically be carried out without continuous supervision and intervention from a diabetic clinician. In addition the legal liability aspect will not be resolved until the manufacturer of a similar system which has resulted in the adverse care of a patient has been pursued through the courts. Recent literature on this subject is based on theory rather than the practical application of law.

14.2 System Evaluation

A protocol, involving four tasks, was devised to perform an initial evaluation (see Chapter 13). satisfying the above ethical considerations. The home based evaluation of data capture facilities were performed in order to obtain user feedback on system acceptabilty. In addition the quantity of data i.e. blood tests, hypoglycaemia etc, recorded was measured. The results indicated a mixed reaction with positive feedback from three of the six participants. The most successful participants were teenagers who used the system independently. All participants agreed that had the system provided advice and diabetic information, recording the blood tests would have been worthwhile.

The clinic based evaluation of data capture and advice facilities allowed the gathering of initial user feedback. The time taken by participants to enter a blood test was measured. In addition the time taken for a participant to obtain system advice was measured. The educational aspect of this system was also investigated. The reaction to the system was mixed and there was no evidence of a link between participant job type and user reaction. However, positive comments were gained from the newly diagnosed families. In addition, time taken by participants to use the system was minimal. Finally, many participants recalled correctly the questions asked by the system, implying the system has an educational benefit.

The patient based evaluation of the advice facilities allowed the problem solving capabilities of patients to be assessed and identified those patients who may most benefit from the system. In addition, a comparison of patients problem solving capabilities with those of the system was carried out. The results of this work showed that the problem solving capabilities of many patients was limited in that they provided incomplete or incorrect solutions. The problem solving capabilities of participants was not related to the parents job type. However, it was evident that long term patients were the most successful problem solvers while the newly diagnosed patients provided the least successful solutions. The solution provided by the system was correct and consistent. In addition comprehensive advice was issued, reminding the user to follow up any action taken with further blood tests.

The clinician based evaluation of the advice facilities provided an opportunity to examine the record keeping of blood tests by diabetic patients. Problems were identified in the diabetic record books (using the blood tests) and the subsequent action taken by the patient was noted. The problems were then presented to the clinician and entered in the Diabetic Management System. The clinician's advice was compared with the system's advice and with the action noted in the diabetic record book. It was concluded that the patients record keeping of diabetic details was poor. The action taken by patients to solve a diabetic problem such as persistent high test results was incomplete i.e. no extra tests taken, and there were some incorrect actions. The clinician's advice and system's advice was similar providing consistent,comprehensive and correct advice.

The methods allowed an initial evaluation of the user interface of the data capture facilities in a home setting. In addition the user interface of the advice facilities was evaluated in the controlled setting of the diabetic clinic. User feedback was obtained on the acceptability of such a system. Finally, the problem solving capabilities of the potential users were assessed.

The general conclusions based on this work are that the home based management of diabetes could be improved. The record keeping of blood tests is poor. The problem solving and diabetic management methods are unsatisfactory and patients do not realise their lack of knowledge.

Although user reaction was mixed, the results of the evaluation indicated the type of diabetic user most likely to find the system acceptable was the younger generation. In addition the user most likely to require problem solving support was identified as the newly diagnosed patient who is not familiar with diabetic problem solving. The long term diabetic families would benefit from the reinforcement of management methods. Furthermore, in order to encourage blood test input the benefit of providing advice and diabetic information must be provided.

User participation of the system in the diabetic clinic resulted in the fast input of blood tests and the obtaining of diabetic advice. In addition, the educational benefit of the system was revealed as participants remembered the questions required to make the correct decisions on insulin adjustment.

The system provided advice that was consistent with that of the clinician. The correct checks were carried out before concluding that insulin should be adjusted and the system reminded the user to take extra tests after the insulin levels had been altered.

When considering the results of the preliminary evaluation it was noted that there was a definite generation gap in the participant's attitude towards the system. It is unlikely that this system will be accepted by the parents currently. This may be due in part to the lack of familiarity with computers. However the diabetic children are, in general, computer literate. Most of the children were familiar with computers through school education and many had a computer at home. This may indicate that in future the Diabetic Management System may be acceptable to more patients. In addition it should be noted that the most successful participants of the home based evaluation were diabetic teenagers who used the system independently.

14.3 User Acceptability

The evaluation stage, which examined the advice section of the system by presenting diabetic problem solving, indicated that many diabetics and/or their family did not perform diabetic problem solving methodically. Few proved that they knew the specific questions that enable the correct decision to be made. Unfortunately many families are not aware of their inadequate diabetic knowledge. This may be one reason why some parents could not see a benefit in this type of system. In addition these findings may indicate a gap in the education of the diabetic child and their family. It is important to note also that there is a gap between what is achievable in blood sugar control by management at home and what is actually done for children with Juvenile Diabetes Mellitus. All this evidence could lead to a reasonable conclusion that there is a need for further supports such as a home based advisor system. Unfortunately the need for the system and its associated benefits does not mean that the system would be accepted (or that the need is even recognised) by potential users.

A similar situation has been identified by Balla et al (1989) when discussing the obstacles to acceptance of clinical decision analysis. Clinicians fail to recognise that there might be a benefit in using decision analysis for diagnosis because they sometimes do not realise the inaccuracies in their decision making.

On a positive note, although several of the parents indicated that they found entering the blood tests on a regular basis time consuming, most agreed that if there was a direct benefit as a result of recording the blood tests the time would be worth spending. Three of the six families involved in the home based evaluation used the system regularly and reacted positively to it.

When considering user acceptablity it is noteworthy that for the generation currently in their teenage years, and those younger, computers will be generally more acceptable because of their familiarity with machines at school (Muse Report, 1985, Primary Contact, 1985). This was illustrated by the home based evaluation of the data capture and interface facilities where the two teenage participants who used the system independently proved to be the most successful users. In addition they reacted positively and enthusiastically to the possibility of such a system. In order to improve user acceptability for the future, diabetic education must be improved for the diabetic child and their family. This may result in potential users appreciating the scope of the system. In the short term, the system should be aimed at the younger generation who are familiar with computers through school education.

The system offers scope for further development including the possibility of implementing parts of the system on a hand held microcomputer. This could be achieved by implementing either the data capture or advice facilities on a Psion Organiser or similar machine (McDonald & Standring, 1988). In addition further enhancements could be included for the user interface. The current system adopted a design suitable for the older diabetic child or parents of a diabetic child. The interface text is held on text files and could easily be amended for the younger diabetic. Finally the current system would benefit from the introduction of colour. This would be relatively easy as the system uses windows throughout the user interface and Turbo Pascal 4.0 has extensive colour facilities.

The ethical and legal considerations remain an unsolved problem for the developer of medical decision support systems. Particularly the system based in the home and designed for the individual non expert. Home computers are commonplace and it is therefore feasible to consider the development of home based advisors although the legal and ethical implications remain. The evaluation stage has indicated that this system would provide some positive benefit to sufferers of Juvenile Diabetes Mellitus. Those who are likely to find the system most acceptable are the younger generation who are familiar with computer technology from an early age. The system can provide accurate, consistent advice that would aid blood sugar control and offer an educational benefit for those managing insulin dependent diabetes.

REFERENCES

Adams I.D., Chan M., Clifford P.C., Cooke W.M., Dallos V.,De Dombal F.T., Edwards M.H., Hancock D.M., Hewett D.J., McIntyre N., Somerville P.G., Speigelhalter D.J., Wellwood J., Wilson D. (1981)
"Computer Aided Diagnosis of Acute Abdominal Pain: A Multicentre Study", British Medical Journal, 293, September, 280-293.

Albisser A.M. (1987 a)
"Metabolism, Chaos and the Design of Expert Medical Systems",Proceedings of the Ninth Annual Conference on the IEEE Engineering in Medicine and Biology Society, Boston MA, USA, 2, 665-6.

Albisser A.M. (1987 b)
"The Development of an Intelligent System for the Diabetic", Biomedical Measurement Information and Control, 2,1, 3-9.

Albisser A.M. Schiffrin A, Schultz M, Tiran J, Leibel B.S. (1986)
"Insulin Dosage Adjustment Using Manual and Computer Algorithms: A Comparative Study", Medical and Biological Engineering and Computing, 577-584.

Albisser A.M. Schultz M.(1986)
"Simulating Human Intermediary Metabolism: OMNI", Conference Proceedings: Clinical Biochemistry Nearer the Patient II, Editors Marks V., Albertti K.G.M.M., 59-67.

Allouche R.A., Aurengo A., Auvert B, Tavernier H, Le Beux P., Hautecouverture (1983)
"A Specific Portable Microcomputer Dedicated to Diabetes Mellitus Therapy Integrated in a Three Levels Information Systems", Medinfo, 804-807.

Alric R., Quatrefages R., Comallonga J. (1980)
"An Electrocapillary Flowmeter Usable as a Quantitive Sweat Detector", Journal of Applied Physiology, 42, 2, 342-346.

Alvey P. (1983)
"The Problems of Designing a Medical Expert System", British Computer Society Workshop, Proceedings of the Specialist Group on Expert Systems, Cambridge Press, 30-43.

Ambrose J., Hounsfield G. (1973)
"Computerized Transverse Axial Tomography", British Journal of Radiology, 46, 148-9.

Ambrosiadou V. (1990)
"DIABETES : An Expert System For Education in Diabetes Management", In Expert System Applications, Ed. Vadera S., Sigma Press, Wilmslow.

Ambrosiadou V., Boulton A. (1988)
"Knowledge Based Systems for Education in Diabetes Management", In 12th IMACS World Congress, Scientific Computation, Paris.

Ambrosiadou V., Boulton A., Masson E. (1988)
"An Expert System for Education in Diabetes Management and Complications", In British Diabetic Association Workshop, Poster Session, Sterling, Scotland, September.

Anderson R.M. (1983)
"Defining and Evaluating Diabetes Patient Education", Diabetes Care, 6, 619-620.

Armitage P., Gehan E.A. (1974)
"Statistical Methods for the Identification and Use of Prognostic Factors", International Journal of Cancer, 13, 16-36.

Bailey R. W. (1982)
"Human Performance Engineering, A Guide for System Designers", Prentice Hall, London.

Balla J.I., Elstein A.S., Christensen C. (1989)
"Obstacles to Acceptance of Clinical Trials",British Medical Journal, 298, 579-582.

Baumer J.H., Edelsten A.D., Howlett B.C., Owens C., Pennock C.A., Savage D.C.L. (1982)
"Impact of Home Blood Glucose Monitoring on Childhood Diabetes", Archives of Disease in Childhood, 57, 195-199.

Benyon D., Milan S., Murray D. (1988)
"Modelling Users Cognitive Abilities in an Adaptive System", NPL Report DITC 115/88.

Benyon D., Murray D., Innocent P.R. (1987)
"System Adaptivity and the Modelling of Stereotypes", Proceedings Interact '87 Second IFIP Conference on Human Computer Interaction, North Holland, Amsterdam.

Blackshear P.J. (1982)
"Insulin Infusion Pumps In the Treatment of Diabetes", Medical Instrumentation, 6, 1, 17-19.

Bleich H.L. (1971)
"The Computer as a Consultant", New England Journal of Medicine 284, 141-147.

Blum B.I. (1986)
"Artificial Intelligence and Medical Information", Medical Informatics, 11, 1, 3-18.

Boroujerdi M.A., Carson E.R., Harvey F.E., Williams C.D., Sonksen P.J. (1987 a)
"DIABETA - A Knowledge Based System for the Management of Diabetes", Proceedings of the Ninth Annual Conference on IEEE Engineering in Medicine and Biology Society, Boston, MA, USA, 2, 667-8.

Boroujerdi M.A., Williams C.D., Piwernetz K. Carson E.K., Hepp K.D., Sonksen P.H. (1987 b)
"Simulation Approach for Planning Insulin Regimes", Advanced Models for Therapy and Insulin Dependent Diabetes , Editors Brunetti, Waldhouse W.K. New York, Raven.

Borthwick L.J., Ross I.S. (1979)
"Performance of Blood Glucose Meters", The Lancet, April 28, 924.

Brown R. (1985)
"The Electronic Expert Teams up With Human Skills", Computing The Magazine Feb 21, 10-11.

Burgess C., Swigger K. (1986)
"A Graphical Database Interface for Casual Name Users", Information Processing Management, 22, 6, 511-521.

Butterworth's Medical Dictionary, Macdonald Critchley, 1978.

Campbell J.A. (1984)
"The Computer Expert and Professional Negligence : Who is Liable", In M. Yazdani, Editor Narayanan A., Artificial Intelligence :Human Effects, 37-51, Ellis Horwood, Chichester.

Cannataci J. A. (1989)
"Liability for Medical Expert Systems : An Introduction to the Legal Implications", Medical Informatics, 14 (3), 229-241.

Carroll J.M., McKendree J. (1987)
"Interface Design Issues for Advice giving Expert Systems", Communications of the ACM 30, 1, 14 - 31.

Chung P.W.H., Kingston J.K.C. (1988)
"State of the Art of Knowledge-Based System Toolkits", British Informatics Society, Expert Systems in Medicine, Fifth Annual Meeting, 29th March, London.

Clarke R. (1988)
"Legal Aspects of Knowledge-Based Technology", Journal of Information Technology, 3 (1), 9-16.

Clocksin W.F., Mellish C.S. (1987)
Programming in Prolog, (Third Edition), New York, Springer-Verlag.

Cohen M., Zimmet P.Z. (1980)
"Home Blood Glucose Monitoring", The MedicalJournal of Australia, 2, 13, 713-6.

Cook D.F., Whittaker A.D. (1989)
"Legal Issues of Expert System Use", Applied Artificial Intelligence, 3 (1), 69-81.

Cook G.B. (1982)
"The Micro Computer: An Extension of The Diabetic Educator", The Diabetes Educator, 7, 4, 12-14.

Craig O. (1981)
"Childhood Diabetes and its Management", 2nd Edition, Butterworths, London.

Cruickshank P.J. (1984)
"Computers in Medicine: Patient's Attitudes". Journal of the Royal College of General Practitioners, February, 77-80.

Davies M., Hakiel S., (1988)
"Knowledge Harvesting : A Practical Guide to Interviewing", Expert Systems, 5, 1, 42-50.

Davis R., King J. (1977)
"An Overview of Production Systems", In Man Machine Representations of Knowledge, Editors Elcock E.W., Michie D., Wiley, New York.

Davis R., Lenat D. (1982)
"Knowledge Systems in Artificial Intelligence", Chapters 5 & 6, McGraw Hill, USA.

Day J.L. (1983)
"Diadata", 19th Annual Meeting of the European Association for the Study of Diabetes, Oslo, Norway.

De Dombal F.T. (1980)
"Diagnosis of Acute Abdominal Pain", Tidsskr Nov Loegeforen nr 31, 100 1852-1855.

De Dombal F.T. (1983)
"Towards a More Objective Evaluation of Computer - Aided Decision Support Systems", Medinfo, 436-439.

De Dombal F.T. (1984)
"Computer Aided Diagnosis of Acute Abdominal Pain - The British Experience", Revue D'Epidemiologie et De Sante Publique, 32, 50-56.

De Dombal F.T., Clamp S., Softly A., Unwin B., Staniland J.R. (1986)
"Prediction of Individual Patient Prognosis Value of Computer Aided Systems", Medical Decision Making, 6, 1, 18-22.

De Dombal F.T., Leaper D.J. Horrocks J.C., Staniland J.R., McCann A.P. (1974)
"Human and Computer-Aided Diagnosis of Abdominal Pain. Further Report with Emphasis on Performance of Clinicians", British Medical Journal, 1, 376-380.

De Dombal F.T., Leaper D.J., Staniland J.R., McCann A.P., Horrocks J.M. (1972).
"Computer Aided Diagnosis of Acute Abdominal Pain", British Medical Journal, 2, 9-13.

Dekeyser L.J., Willems J.L. (1986)
"The Impact of the Control Structures of Medical Expert Systems on the User Interface", Human Computer Communications in Health Care, 247-256.

De Meijer F.H.E.M., Meinders A.E. (1984)
"The Effect of Home Blood Glucose Monitoring in Type 1 Diabetes Mellitus: An Effect of Education", Netherlands Journal of Medicine, 27, 5, 179-184.

Department of Trade and Industry (1985)
"Implementation of EEC Directive on Product Liability. An Exploratory and Consultative Note.", HMSO, London.

De Vries P.H., de Vries Robbe P.F. (1985)
"An Overview of Medical Expert Systems", Methods of Information in Medicine, 24, 57-64.

Dowie J. (1990)
"The Evaluation of Decision Aids : The Role of the Decision Owner", Medical Informatics, To Be Published.

Du Boulay G.M., Teather D., Morton B.A., Wills K.M., Innocent P.R., Plummer D., (1987).
"BRAINS - A Computer Advisor System to Aid in CT Scan Interpretation and Cerebral Disease Diagnosis", Neuroradiology, 29, 194-196.

Duda R.O., Hart P.E. (1973)
"Pattern Classification and Scene Analysis", Wiley, New York.

Duda R.O., Shortliffe E.H. (1983)
"Expert Systems Research", Science, 220, 261-268.

Edmonds E. (1982)
"The Man-Computer Interface: A Note on Concepts and Design", International Journal of Man Machine Studies, 16, 231-6.

Elstein A.S., Shulman L.S., Sprafka S.A. (1978)
"Medical Problem Solving: An Analysis of Clinical Reasoning", Cambridge M.A., Harvard University Press.

Erlich R.M. (1982)
"Diabetes Mellitus in Children", Clinics in Endocrinology and Metabolism, 11, 1, 195-210.

Essex D.L., Sorlie W.E. (1979)
"Effectiveness of Instructional Computers in Teaching Basic Medical Science", 13, 3, 89-83.

Essig M.J. (1983)
"Taking a Careful Look at Diabetes Education in Hospitals", American Journal of Nursing, 83, 12, 1700.

Expert Systems User (1989 a)
"New Developments in the Medical World", January, 6-9.

Expert System User (1989 b)
"The Law and Expert Systems", February, 10-11.

Falkenberg M. (1983)
"Diabetes Instruction : The KISA Model", Diabete and Metabolisme (Paris), 9, 164.

Feischi M., Joubert M., (1986)
"Some Reflections on The Evaluation of Expert Systems in Medicine", Methods of Information in Medicine, 25, 15-21.

Frazier L.M., Neelon F.A., (1984)
"Insulin Can Make Diabetes Worse : The Smouldering Somogyi Effect", North Carolina Medical Journal 4, 5, 6,396-8.

Fries J.F. (1976)
"A Data Bank for the Clinician?", (editorial), New England Journal of Medicine, 294, 1400-140.

Gale E.A.M. (1980)
"Hypoglycaemia", Clinics in Endocrinology and Metabolism, 9,3, 461-75.

Gale E.A.M., Kurtz A.B., Tattersall R.B. (1980)
"In Search of the Somogyi Effect", The Lancet, 279-282.

Garland L.H. (1959)
"Studies on the Accuracy of Diagnostic Procedures", American Journal of Roentgenology, 82, 25-38.

Ginsberg J., Fink R. (1983)
"Diabetes Mellitus", Medical Education, 369-378.

Goering R. (1984)
"Do it Yourself Development Tools Speed Al Applications", Computer Design, USA, December, 23, 14, 29-32, 37-39.

Golden M., Siemens R.W., Ferguson J.C. (1986)
"Whats Wrong With Rules?", I.E.E.E. Western Conference on Knowledge Based Engineering and Expert Systems, USA, June, 162-5.

Gorman C.K. (1965)
"Hypoglycaemia : A Brief Review", Medical Clinic of North America, 49, 947-957.

Gorry G.A., Kassirer J.P., Essig A., Schwartz W.B. (1973)
"Decision Analysis as the Basis for Computer Aided Management of Acute Renal Failure", American Journal of Medicine, 55, 473-484.

Hansen K.A., Duck S.C. (1983)
"Teledyne Sleep Sentry: Evaluation in Paediatric Patients For Detection of Nocturnal Hypoglycaemia", Diabetes Care, 6, 6, Nov - Dec, 597-600.

Harvey F.E. (1988)
"Diabeta: A Computer Based Interactive Advisory System for the Management of Diabetes", Diabetes Research and Clinical Practice, Suppl. Vol 5., Page S19.

Harvey F.E., Carson E.R. (1985)
"Diabeta - An Expert System for the Management of Diabetes", Objective Medical Decision Making Systems Approach in Disease, Workshop, Crete, Greece, 166-174.

Hess G.E., Davis W.K., (1983)
"The Validation of a Diabetes Patient Knowledge Test", Diabetes Care, 6, 6, 591-596.

Hovorka R., Andreassen S., Benn J.J., Carson E.R., Kjaerluff U., Kristensen L.D., Olesen K.G. (1990)
"Causal Probabilistic Network Model to Assist Insulin Therapy Adjustment", Expert Systems in Medicine, Proceedings of the 6th Annual Meeting, 21 - 22 June 1990, 73-74.

Huang H.K., Wu S.C. (1976)
"The Evaluation of Mass Densities of Human Bodies in Vivo from Scans", Computing in Biology and Medicine, 6, 4, 337-43.

Hyman W.A. (1988)
"Liability and Risk Management for Defective Expert Systems", Proceedings of the Annual International Conference of the IEEE Engineering in Medicine & Biology Society, 10 (3), New Orleans, 1397.

Inada H., Naito M., Inoue M. Abe H., Furukawa T. (1978)
"A Computer Based Clinical Supporting System", Proceedings of the International Conference on Cybernetics and Society, 1, 254 - 7.

Jette D.U. (1984)
"Physiological Effects of Exercise in the Diabetic", Physical Therapy, 64, 3, 339-42.

Jovanovic L., Peterson C.M. (1982)
"Home Blood Glucose Monitoring", Diabetes 8, 1, 10-20.

Judd S., Sonksen P.H. (1980)
"Teaching Diabetic Patients About Self Management", Diabetes Care 3, 1, 134-139.

Karat J., McDonald J.E., Anderson M. (1986)
"A Comparison of Menu Selection Techniques: Touch Panel, Mouse, Keyboard", International Journal of Man Machine Studies, 25, 73-88.

Kassirer J.P., Gorry G.A. (1978)
"Clinical Problem Solving: A Behavioural Analysis", Annals of Internal Medicine, 89, 245-255.

Kidd A. L., Cooper M.B. (1983)
"Man - Machine Interface for an Expert System", Proceedings of the 3rd Conference of the British Computer Society Specialist Group on Expert Systems, British Computer Society Workshop Series, Cambridge Press, 8-19.

Kiger J.I. (1984)
"The Depth/Breadth Trade Off in the Design of Menu Driven User Interfaces", International Journal of Man-Machine Studies, 20, 2, 201-213.

Kikuchi M., Machiyania E., Kabei N., Yamada A., Sukarai Y., Hara Y., Sano A., (1980)
"Adaptive Control System of Blood Glucose Regulation", Proceedings of the 3rd World Conference on Medical Informatics Medinfo 80, 1, 96-100.

Kinmonth A.L., Greene S., Strong S., Todd L., Smith A., Baum D.(1982)
"An Introduction to Diabetes", 2nd Edition, Ames, Slough.

Kiser D. (1980)
"The Somogyi Effect", American Journal of Nursing, 80, 2, 236-8.

Kohout L.J., Bandler W., Anderson J., Trayner C. (1986)
"Clinical: A Knowledge - Based Decision Support System for Use in Medicine", Computer Assisted Decision Making, 133-146.

Korhonen T., Huttunen J.K., Hentinen M., Ihalainen O., Majander H., Siitonen O., Uusitupa M., Pyorala K. (1983)
"A Controlled Trial on the Effects of Patient Education in the Treatment of Insulin - Dependent Diabetes", Diabetes Care, 6, 256-61.

Kulikowski C. (1980)
"Artificial Intelligence Methods and Systems for Medical Consultation", IEEE Transactions on Pattern Analysis and Machine Intelligence, PAM 1- 2, No.5, 464-476.

Lafferty H.H., Giddings A.E.B., Mangall D., (1978)
"A Digital Computer Model For Glucose Insulin Dynamics", Computing in Biology and Medicine, 8, 1, 41-55.

Levandoski L., White N.M., Popp D., Santiago J.V. (1981).
"Teledyne Sleep Sentry (R) A Possible Aid for the Detection of Symptomatic Nocturnal Hypoglycaemia in Insulin Dependent Diabetics", International Symposium on Artificial Systems of Insulin Delivery (Assisi, Italy 1981), Kanan Press, New York.

Levy M., Ferrand P., Boisvieux J.F. (1987)
"SESAM - Diabeta an Expert System for Insulin Requiring Diabetic Patients Education", Proceedings of the Ninth Annual Conference on IEEE Engineering in Medicine and Biology Society, Boston MA, USA, 2, 671-672.

Liang J.P. (1987)
"User Interface Design for Decision Support Systems: A Self Adaptive Approach", Information and Management (Netherlands) 12, 4, 181-93.

Lipkin M., Hardy J.D. (1958).
"Mechanical Correlation of Data in Differential Diagnosis of Hematologic Diseases". Journal of the American Medical Association, 166, 13-125.

MacDonald M. (1983)
"Personal Blood Glucose Testing In Children", Primary Care, 10, 4.

Maddock R.K., Krall L.P. (1953)
"Insulin Reactions", Archives of Internal Medicine, 91, 6, 695-703.

Maguire M. (1982)
"An Evaluation of Published Recommendations on the Design of Man-Computer Dialogues", International Journal of Man Machine Studies, 16, 237-261.

Mashima M., Nomura Y. (1986)
"An Approach to Diagnostic Aid Using Symptom/Sign and Routine Blood Test", Automedica, 7, 17-31.

Matsumura Y. (1986)
"RHINOS : A Consultation System for Diagnosis of Headache and Facial Pain", Computer Methods and Programs in Biomedicine, 23, 65-71.

Mazze R. S., Zimmet P. (1987)
"Computers in Diabetes Care and Patient Education an Overview", Practical Diabetes, 4(1),8-11.

McCullock D.K., Mitchell R.D., Ambler J, Tattersall R.B. (1985)
"A Prospective Comparison of Conventional and High Carbohydrate/High Fibre/Low Fat diets in Adults with Established 'Type 1' (insulin dependent) Diabetes", Diabetologia, 28, 208-212.

McDonald S.P., Standring G.L. (1988)
"The Psion Organiser II as a Data-Collection Tool for Dental Research and Evaluation", British Dental Journal, 164, 12, 404-405.

McNeal B., Salisbury Z., Baumgardner P., Wheeler F.C. (1984).
"Comprehension Assessment of Diabetes Education Program Partcipants", Diabetes Care, 7,3, May-June, 232-235.

Meadows K. A., Fromson B., Gillespie C., Brewer A., Carter G., Lockington T., Clark G., Wise P.H. (1988)
"Development Validation and Application of Computer Linked Knowledge Questionnaires in Diabetes Education", Diabetic Medicine, 5, 61-67.

Menn S.J., Barnett G.O. Schmechiel D., Owens W.D., Pontoppidan M., (1973)
"A Computer Program to Assist in the Care of Acute Respiratory Failure", Journal of the American Medical Association, 223,308-312.

Miller P.L. (1986)
"The Evaluation of Artificial Intelligent Systems in Medicine", Computer Methods and Programs in Biomedicine, 22, 5-11.

Miller R.A. (1987)
"Legal Issues Related to Medical Decision Support Systems", International Journal of Clinical Monitoring and Computing, 6 (2), 75-80.

Mirouze J. (1977)
"Continuous Blood Glucose Monitoring in Insulin-Treated Diabetes", Hormone Metabolic Research, 7, 77-86.

Morrisett W. (1984)
"More on Patient Education: Use of Microcomputers", Diabetes Care, 7, 1, Jan-Feb, 105.

Mortimer H. (1989)
"Computer-Aided Medicine : Present and Future Issues of Liability", Computer/Law Journal, IX, 177-203.

Morton B.A., Teather D., du Boulay G.H. (1984)
"Statistical Modelling and Diagnostic Aids", Medical Decision Making, 4, 3, 339-48.

Mosier J.N., Smith S.L. (1986)
"Application of Guidelines for Designing User Interface Software", Behavior and Information Technology, 5, 1, 39-46.

Muir B.M. (1987)
"Trust Between Humans and Machines and the Design of Decision Aids", International Journal of Man-Machine Studies, 27, 527-539.

Munro N., Palaskas, Z.V. (1987)
"An Adaptive Dialogue Facility", IEEE Colloquim on The Use of Expert Systems in Control Engineering (Digest no. 27), 5, 1-4.

Murray T.S., Cupples R.W., Barber J.H. (1977)
"Teaching Decision Making to Medical Undergraduates by Computer Assisted Learning", Medical Education, 11, 4, 262-4.

Musen M.A., Fagan L.M., Shortliffe E.H. (1986).
"Graphical Specification of Procedural Knowledge for an Expert System", IEEE Computer Society Workshop on Visual Languages, 167-177.

Muse Report, No. 7, (1985)
Microcomputer Users in Secondary Education, PO Box 43, 231/1 Friary Chambers, Whitefriargate, Hull, HU1 2DH.

Myers J.D., Pople H.E., Miller R.A. (1982)
"Internist : Can Artificial Intelligence Help?" In Clincial Decision and Laboratory Use, Editors Connelly, Benson, Birke, Fenderson, 251-269 Minneapolis MN: University of Minnesota Press.

Nemes L. (1987)
"Intelligent Interfaces", Robotics and Computer Integrated Manufacturing, 5, 2, 171-174.

Newman W.P. (1987)
"A Comparison of Automatic Algorithms For Insulin Adjustment via a Computer Model of Diabetes Mellitus", Biomedical Science Instrumentation, 23, 125-127.

Oakley, Pyke and Taylor (1978)
"Diabetes and Its Management", Blackwell, London.

O'Kane K.C. (1986)
"An Expert System Facility for Mumps", Computing in Biology and Medicine, 16, 3, 205-213.

Oleson C. (1977)
"Internist: A Computer-Based Consultation", In Computer Networking in the University: Success and Potential, EDUCOM, USA.

Olson J.R., Rueter H.H. (1987)
"Extracting Expertise From Experts: Methods for Knowledge Acquistion", Expert Systems, 4, 3, 152-168.

Parfrey P.S., O'Sullivan D.J., Lyon F. (1978)
"Methods of Assessment of Short Term Diabetic Control", Irish Journal of Medical Science, 147, 8, 276-82.

Paxton A.L., Turner E.J. (1984)
"Human Factors and Novice Computer Users", International Journal Man Machine Studies, 20, 137-156.

Perlstein P.H., Edwards N.K.,Atherton H.D.,Sutherland J.M. (1976)
"Computer Assisted Newborn Intensive Care", Pediatrics, 57, 4, 494-501.

Pernick N., Beveridge M., Jaffe M.L., Parker R., Rodbard (1983)
"A Microcomputer Consultation System for Self Adjustment of Insulin Dosage",Medical Management, 2, 62-67.

Pfeiffer E.F., Thurn C.H. Raptis S., Beischer W.; Ziegler R. (1976)
"Hypoglycaemia in Diabetes", Hormone Metabolic Research 6, 112-26.

Pickert J.W. (1983)
"Not all Medicines (or Patient Education Programs) are the same", Diabetes Care, 6, 6, Nov-Dec, 618-619.

Pickup J.C. (1982)
"Preliminary Evaluation of a Skin Conductance Meter for Detecting Hypoglycaemia in Diabetic Patients", Diabetes Care, 5, 3, 326-329.

Pickup J.C. (1983)
"Practical Experiences with Insulin Infusion Pumps", Acta Medica Scandinavica, 671, 139-141.

Pickup J.C., Keen H., Parsons J.A., Alberti K.G.M.M., Rowe A.S. (1979)
"Continuous Subtucaneous Insulin Infusion Improved Blood-Glucose and Intermediary Metabolite Control in Diabetics", The Lancet, June 16, 1255-1261.

Pocock S. J. (1984)
"Clinical Trials A Practical Approach", J. Wiley & Sons, London.

Pople H. (1975)
"Artificial Intelligence Approaches to Computer Based Medical Consultation", In Proceedings of the IEEE, INTERCON 31 (3), 1-7.

Prater B. (1983)
"Education Guidelines For Self Care Living with Diabetes", Journal of the American Dietetic Association, 82, 3, 283-286.

Primary Contact, (1985). Special Issue No. 3
Microcmputers Didsbury school of Education, Manchester Polytechnic.

Prutting J. (1967)
"Lack of Correlation Between Antemortem and Postmortem Diagnosis", New York Journal of Medicine, 67, 2081-2084.

Ramsey C.L., Reggia J.A., Nan D.S., Ferrentino A., (1986)
"A Comparative Analysis of Methods For Expert Systems", International Journal of Man Machine Studies, 24, 475-499.

Reed C. (1990)
"Expert Systems", In Computer Law ,Blackstone Press, London.

Richards J.N.J., Bez H.E., Gittins D.T., Cooke D.J. (1986)
"On Methods for Interface Specification and Design", International Journal of Man Machine Studies, 24, 545-568.

Rodbard D., Pernick N., Jaff M. (1984)
"Diabetes Data Management Program Available for Microcomputers", Diabetes Care, 7, 4, July-Aug, 401-402.

Rosenblatt M.B., Teng P.K., Kerpe S. (1973)
"Diagnostic Accuracy in Cancer as Determined by Post-Mortem Examination", Progress in Clinical Cancer, 5, 71-80.

Ruszowski J. (1986)
"Elsa - A Method For Medical Knowledge Acquisition and Processing to Aid Medical Reasoning", Methods of Information in Medicine, 25, 2, 79-86.

Schiffrin A. (1988)
"New Devices for Patients with Diabetes Mellitus : A Reply", Diabetes Care, January, 11 (1), 98-99.

Schiffrin A., Mihic M., Leibel B.S., Abisser A.M., (1985)
"Computer Assisted Insulin Dosage Adjustment", Diabetes Care, 8, 6, Nov-Dec, 545-552.

Schmitt J.K., Poole J.R., Lewis S.B. (1980)
"A Computer - Orientated Diabetes Clinic: Assessing the Benefits of Diabetic Control", Proceedings of the 4th Annual Symyposium on Computer Application in Medical Care, pt 11, Washington DC, USA, 1044-1048.

Sharratt B. (1989)
"The Pragmatics of Interface Evaluation", Tutorial Notes, HCI,University of Nottingham, September.

Sherman M., Reiffen B., Komaroff A.L. (1973)
"Ambulatory Care Systems", In Problem Directed and Medical Information Systems ed. M.F. Driggs, Intercontinental Medical Book Corporation, New York, 143-171.

Shipp J.C. (1968)
"Excess Insulin in the Diabetic Frequency Consequences and How to Detect", Journal of the Florida Medical Association, (USA), 55, 3, 194-9.

Shneiderman B. (1986)
"Designing Menu Selection Systems", Journal of the American Society for Information Sciences, 37, 2, 57-70.

Shneiderman B. (1987)
"Designing the User Interface, Strategies for Effective Human-Computer Interaction", Reading, Mass, Addison-Wesley.

Shortliffe E.H., (1976)
"Computer Based Medical Consultations : MYCIN", American Elsevier, New York.

Shortliffe E.H., Buchanan B.G. Feigenbaum E.A. (1979)
"Knowledge Engineering For Medical Decision Making", A Review of Computer-Based Clinical Aids II Proc. IEEE (USA) 67, 9, 1207-1224.

Shortliffe E.H., Davis R. (1975)
"Some Considerations for the Implementation of Knowledge-Based Expert Systems", SIGART Newsletter, 55, 9-12.

Silas J.H., Grant D.S., Maddocks J.L. (1981)
"Transient Hempartic Attacks Due to Unrecognised Nocturnal Hypoglycaemia", British Medical Journal, 282, 132-133.

Sisson N., Parkinson K., Snowberry K. (1986)
"Considerations of Menu Structure and Communication Rate for the Design of Computer Menu Displays", International Journal of Man Machine Studies, 25, 479-488.

Skyler J.S., Skyler D.L., Lasky I.L., Lebovitz (1979)
"Instructing Patients in Making Alterations in Insulin Dosage", Diabetes Care, 2, 1, 39-45.

Skyler J.S., Skyler D.L., Seigler D.E., O'Sullivan M.J. (1981)
"Algorithms for Adjustment of Insulin Dosage by Patients who Monitor Blood Glucose", Diabetes Care, 4, 311-318.

Smith M.A., Greene S.A., Kuykendall V.G.,, Baum J.D. (1985)
"Memory Blood Glucose Reflectance Meter and Computer: A Preliminary Report of its Use in Recording and Analysing Blood Glucose Data Measured at Home by Diabetic Children", Diabetic Medicine, 2, 265-268.

Smith S.L. (1986)
"Standards Verses Guidelines for Designing User Interface Software", Behaviour and Information Technology, 5, 1, 47-61.

Somogyi M. (1938)
"Hypoglycaemic Response to Hypoglycaema in Diabetic and in Healthy Individuals",Proceedings of the Society for Experimental Biology and Medicine, 38, 51-5.

Sonksen P.H. (1980)
"Home Monitoring of Blood Glucose by Diabetic Patients ", Acta Endocrinologica, 194, Suppl. 238, 145-155.

Sonksen P.H., Judd S.L., Lowy C. (1978)
"Home Monitoring of Blood Glucose: Method for Improving Diabetic Control", The Lancet, April, 729-735.

Sonksen P.H., Judd S.L., Lowy C. (1980)
"Home Monitoring of Blood Glucose: New Approach to Management of Insulin Dependent Diabetic Patients in Great Britain", Diabetes Care, 3, 1, Jan 100-101.

Spavold J. (1990)
"The Child as a Naive User : A Study of Database Use with Young Children", International Journal of Man - Machine Studies, 32, 603-625.

Speller G. J., Brandon J.A. (1986)
"Ethical Dilemmas Constraining the use of Expert Systems", Behavior and Information Technology, 5 (2),141-143.

Spiegalhalter D.S. (1983)
"Evaluation of Clinical Decision Aids With An Application to a System for Dyspepsia", Statistics in Medicine, 2, 207-216.

Stamper R. (1988)
"The Dangers of AI in Information Systems as Exposed by the Field of Computer and Law", Journal of Information Technology, 6-8.

Strowig S. (1982)
"Patient Education: A Model for Autonomous Decision-Making and Deliberate Action in Diabetes Self Management", Medical Clinics of North America, 66, 6, 1293-1307.

Sussman K.E., Crout R., Marble A. (1963)
"Failure of Warning in Insulin Induced Hypoglycaemic Reactions", Diabetes, 12, 1, 38-45.

Tamborlane W.V., Sherwin R.S., Genel M., Felig P. (1979)
"Reduction to Normal of Plasma Glucose in Juvenile Diabetes by Subtucaneous Administration of Insulin with a Portable Infusion Pump", New England Journal of Medicine, 300 (11), 537-538.

Tattersall R., Gale E. (1981)
"Patient Self Monitoring of Blood Glucose and Refinements of Conventional Insulin Treatment", The American Journal of Medicine, 70, 177-81.

Teather D., Emerson P.A., Handley A.J. (1974)
"Decision Theory Applied to the Treatment of Deep Vein Thrombosis", Methods of Information in Medicine, 13, 2, 92-97.

Teather D., Morton B.A., du Boulay G.H., Wills K.M., Plummer D., Innocent P.R. (1985)
"Computer Assistance for CT Scan Interpretation and Cerebral Disease Diagnosis", Statistics in Medicine, 4, 311-315.

Theveriot D. (1982)
"Problems in Adapting a Glucose Oxidase Implantable Glucose Sensing Device", Diabetes Care, 5, 3, 184-202.

Valenta C.L. (1983)
"Urine Testing and Home Blood Glucose Monitoring", Nursing Clinics of North America, 18, 4, 645-659.

Van Hoe R., Poupeye K., Vandierendonk A., De Soete G. (1990)
"Some Effects of Menu Characteristics and User Personality on Performance with Menu-Driven Interfaces", Behavior & Information Technology, 9 (1), 17-29.

Varma S.K. (1979)
"Hypoglycaemia in Infancy and Childhood", Southern Medical Journal, 72, 1, 57-64.

Victoroff M.S. (1985)
"Ethical Expert Systems", Proceedings of the 9th Annual Symposium on Computer Applications in Medical Care, 644-648.

Wagner G., Tautu P., Wolber N. (1978)
"Problems of Medical Diagnosis : A Bibliography", Methods of Information on Medicine 17, 55-74.

Warzak W., Ayllon T., Delcher H. (1982)
Instruction of Home Glucose Monitoring", Diabetes Care, 5, 1, 44-6.

Wexelblat R. (1989)
"On Interface Requirements for Expert Systems", AI Magazine, Fall, 66-78.

Weyl S., Fries J., Wiederhold G.,Germano F. (1975)
"A Modular Self Describing Clinical Databank System", Computers and Biomedical Reserach 8, 279-293.

Wigertz O. (1986)
"Making Decisions Based On 'Fuzzy' Medical Data - Can Expert Systems Help?", Methods of Information In Medicine, 25, 59-61.

Williams C.D., Harvey F.E., Sonksen P.H. (1988)
"A Role For Computers in Diabetic Care?", Diabetes Care, 5, 2, 177-99.

Winston P.H., Horn B. (1981)
"LISP", Reading MA: Addison Wesley.

Wise P.H. (1987)
"Computer Application in Diabetes Education", Practical Diabetes, 4 (3), 111 - 113.

Wise P.H., Dowlatshahi D.C., Farrant S., Fromson S., Meadows K.A. (1986)
"Effect of Computer Based Learning on Diabetes Knowledge and Control", Diabetes Care, 9 (5).

Wyatt J. (1990)
"Implications of Legal Liability for Medical Expert Systems", Proceedings of the 6th Annual Meeting of Expert Systems in Medicine, Published by British Medical Information.

Yoshizawa K., Ichinose M., Nishitani H., Tanaka M. (1979)
"Study on the Reaction Between Nocturnal Hypoglycaemia and Fasting Blood Sugar Levels in Diabetics Treated with Hypoglycaemic Agents", Osaka City Medical Journal, 25, 1, 1-6.

Yu V.L., Buchanan B.G., Shortliffe E.H., Wraith S.M., Davis R., Scott A.C., Cohen S.N. (1979 a)
"Evaluating the Performance of a Computer Based Consultant", Computer Programs in Biomedicines, 9, 95-102.

Yu V.L., Fagan L.M., Wraith S.M., Clancey W.J., Scott A.C., Hannigan J.F., Blun R.L. Buchanan B.C., Cohen S.N. (1979 b)
"Anti Microbial Selection by a Computer. A Blinded Evaluation by Infections Disease Experts", Journal of the American Medical Association 242, 12, 1279-1282.

Zeide J.S., Leibowitz J. (1987)
"Using Expert Systems : The Legal Perspective", IEEE Expert, 2 (1), 19-21.

APPENDIX I

DIABETIC CHILDREN'S CLINIC - SAMPLE NOTES

Children's Diabetic Clinic, Leicester Royal Infirmary
Clinician - Dr. Peter Swift

1. Personal Details :
Sex : Male
Age : -

Notes :

a) Discussion about tablets prescribed for epilepsy.

b) Discussion on the patients epilepsy.

c) Comment on his height and weight.

Problems & Comments.

The majority of the time was taken up with the family problems of the child. The mother was a registered psychiatric patient which made the interview difficult to follow.

2. Personal Details :
Sex : Male
Age : 5
Term : Had not been diagnosed diabetic for very long. In remission.

Notes :

a) Examination of log book: Comments were made on both the urine tests and blood tests. Advised to take more blood tests because although the urine tests were very good it is possible to have low urine test results and high blood sugar. This is due to the fact that sometimes sugar takes a long time to travel from the blood to the urine.

b) The site of injection was examined. (site is noted in the log book).

3. Personal Details :
Sex : Female
Age : 12 years
Term : 4 years

Notes :

a) Dr. Swift noted that she had grown considerably since the last clinic.

b) Examination of log book.

The urine test results were high and the blood tests were low. The girl was asked to demonstrate the way she took a blood test. The result of the blood test was high.

c) the girl left the office. The mother explained the girl had started menstruating and Dr. Swift warned the mother to expect higher urine test results at this time.

4. Personal Details.
Sex : Female
Age : 5.75 years

Notes :

a) Dr Swift examined the log book. He paid particular attention to the changes made to insulin levels and the effect on the urine test results.

b) the injection site was checked.

5. Personal Details.
Sex : Female
Age : 7.75 years
Term : 6 months

Notes :

a) Dr. Swift asked if the child had injected herself. Reply: No.

b) Examined effects of insulin change.

c) Comment on log book: "good mixture of bloods and urines".

d) Parents expressed anxiety about the child's moods. They did not know whether it was due to low sugar levels. Dr. Swift advised blood tests to be taken during this time to check.

6. Personal Details
Sex : Male
Age : 10
Term : -

Notes :

a) Dr. Swift examined the log book.

b) Dr. Swift advised the child on entering his own results.

c) The urine test results after playing football were high due to a pre match kit-kat. Advised to cut down on pre match snack.

d) Dr. Swift advised a change in insulin (increase).

When changes in insulin are made in treatment e.g. increase in insulin. A letter is sent to the G.P. Also other letters were recorded between sessions.

7. Personal Details
Sex : Male
Age : 14.75 years
Term : -

Notes :

a) appointment query.

b) Dr. Swift asked why the diabetic had not attended the last summer camp and asked if he would like to join next year.

c) log book was "OK".

d) Dr. Swift noted that he had grown taller and slimmer since last clinic and said it was "good".

e) the boy said he had used a diabetic program in school entering carbohydrate values. Teacher Mr. J. Henshaw, Countesthorpe College.

8. Personal Details.
Sex : Female
Age : 14 years
Term : 3 years

Notes :

a) asked about foot operation - is it related to diabetes.

b) examined log book for effect on urine test results Dr. Swift explained that the results would be higher for a while.

c) Dr. Swift asked if the sugary days were due to menstruation.

d) established next appointment and a note made to see the girl without her mother.

9. Personal Details.
Sex : Male
Age : 16 years
Term : 7 years

Notes :

a) examination of log book.

b) the boy had one kidney due to congenital defect at birth. Therefore should be extra careful to have well controlled diabetics. However the boy was not doing what Dr. swift told him i.e. not turning up to clinics, sugar levels high. N.B. he had the highest Hb A1 (18) in the clinic.

c) the results were negative but there were no evidence of hypos - could indicate the results were not true.

d) established next meeting.

APPENDIX II

ACTION CHARTS

Action Chart

Regime type - 2 injections per day , both mixed.

Read across from time of problem to type of problem for the correct insulin to be adjusted.

Time	Meals	Injections	Hypoglycaemia	High test results
12.00 a.m.				
01.00				
02.00				
03.00			Decrease	Increase
04.00			p.m. long	p.m. long
05.00				
06.00				
07.00	Br	First		
08.00				
09.00				
10.00	Sn		Decrease	Increase
11.00			a.m. quick	a.m. quick
12.00 p.m.				
01.00	Lu			
02.00				
03.00	Sn		Decrease	Increase
04.00			a.m. long	a.m. long
05.00		Second		
06.00	Te			
07.00			Decrease	Increase
08.00	Sn		p.m. quick	p.m. quick
09.00				
10.00				
11.00				

Action Chart

Regime type - 2 injections per day , both ready mixed.

Read across from time of problem to type of problem for the correct insulin to be adjusted.

Time	Meals	Injections	Hypoglycaemia	High test results
12.00 a.m.				
01.00				
02.00				
03.00			Decrease	Increase
04.00			pre tea	pre tea
05.00				
06.00				
07.00	Br	First		
08.00				
09.00				
10.00	Sn			
11.00			Decrease	Increase
12.00 p.m.			pre breakfast	pre breakfast
01.00	Lu			
02.00				
03.00	Sn			
04.00				
05.00		Second		
06.00	Te			
07.00			Decrease	Increase
08.00	Sn		pre tea	pre tea
09.00				
10.00				
11.00				

Action Chart

Regime type - 2 injections per day , one mixed,
one long acting.

Read across from time of problem to type of problem for the correct insulin to be adjusted.

Time	Meals	Injections	Hypoglycaemia	High test results
12.00 a.m.				
01.00				
02.00				
03.00			Decrease	Increase
04.00			p.m. long	p.m. long
05.00				
06.00				
07.00	Br	First		
08.00				
09.00				
10.00	Sn		Decrease	Increase
11.00			a.m. quick	a.m. quick
12.00 p.m.				
01.00	Lu			
02.00				
03.00	Sn		Decrease	Increase
04.00			a.m. long	a.m. long
05.00		Second		
06.00	Te			
07.00				
08.00	Sn			
09.00			Decrease	Increase
10.00			p.m. long	p.m. long
11.00				

Action Chart

Regime type - 4 injections per day , all readymixed.

Read across from time of problem to type of problem for the correct insulin to be adjusted.

Time	Meals	Injections	Hypoglycaemia	High test results
12.00 a.m.				
01.00				
02.00				
03.00			Decrease	Increase
04.00			Pre Supper	Pre Supper
05.00				
06.00				
07.00	Br	First		
08.00				
09.00			Decrease	Increase
10.00	Sn		Pre breakfast	Pre breakfast
11.00				
12.00 p.m.				
01.00	Lu	Second		
02.00				
03.00	Sn		Decrease	Increase
04.00			Pre lunch	Pre lunch
05.00	Te	Third		
06.00			Decrease	Increase
07.00			Pre tea	Pre tea
08.00				
09.00	Su	Fourth		
10.00			Decrease	Increase
11.00			Pre Supper	Pre Supper

APPENDIX III

SHARED PROGRAM MODULES

```
(****************************************************************)
(*                                                              *)
(*     DIABETIC MANAGEMENT SYSTEM : Shared system modules       *)
(*     -----------------------------------------------          *)
(*                                                              *)
(*   Author : Judith Jones                                      *)
(*            Leicester Polytechnic                             *)
(*                                                              *)
(*   Date   :  30.3.89                                          *)
(*                                                              *)
(*     A system to aid the management of insulin dependent     *)
(*     diabetic children.                                       *)
(*                                                              *)
(*   The system consists of nine modules :                      *)
(*                                                              *)
(*        Shared modules                                        *)
(*                           - initialisation                   *)
(*                           - screen and menu control          *)
(*                           - help and general information     *)
(*                           - advice                           *)
(*        Diabetic modules                                      *)
(*                           - input and change data            *)
(*                           - view data                        *)
(*                           - data summaries                   *)
(*        Clinician's system                                    *)
(*                           - print data                       *)
(*                           - change rules and text            *)
(*                                                              *)
(****************************************************************)

(****************************************************************)
(*                                                              *)
(*                  INITIALISATION  MODULE                      *)
(*                                                              *)
(****************************************************************)

unit decl;
uses crt,dos,graph3,scrnops4;
const underln = £196;

type
                               (*   general array structures   *)
     tim       = array[1..3] of word;
     arraysix  = array[1..6] of integer;
     uarray    = array [1..4] of char;
     hyarray   = array[1..2,1..6]of integer;
     insarray  = array[1..2,1..2]of integer;
     arraychar = array[1..6]of char;

                               (*  data capture structures     *)
     btrec = record
       btd : array [1..3] of word;
       bta : array [1..320] of char
    end;
```

```
details = record
  fname    : string;
  totname  : string;
  sex      : string;
  height   : real;
  weight   : real;
  bdate    : string;
  ddate    : string;
end;

cdate  =  record
  clinic_date : tim
end;

daily_tests = record
  dt_date : tim;
  dt_bhrs : arraysix;
  dt_bmin : arraysix;
  dt_btest :arraysix;
  dt_utest :uarray;
end;

daily_extras = record
  d_date  : tim;
  d_diet  : arraysix;
  d_ins   : insarray;
  d_extim : insarray;
  d_extyp : integer;
  d_hy    : hyarray;
  d_he    : arraychar;
  d_em    : uarray;
  d_hol   : integer
end;

blood = record
  bd  : tim;
  btm : arraysix;
  bth : arraysix;
  br  : array[1..6] of real;
end;

urine = record
  ud : tim;
  ur : array [1..4] of real
end;

diet = record
  dd  : tim;
  cho : arraysix
end;

insulin = record
  ind : tim;
  inr : insarray
end;
```

```
exercise = record
  ed    : tim;
  etime : insarray;
  etype : integer
end;

hypos = record
  hyd: tim;
  ht: hyarray
end;

health = record
  hed   : tim;
  htype : arraychar
end;

emotion = record
  emd    : tim;
  emtype :uarray
end;

holidays = record
  hod  : tim;
  hols : integer
end;

regime = record
  noinj   : integer;
  doses   : packed array[1..2,1..2] if integer;
  instyp1 : string;
  instyp2 : string;
end;

                                  (*   rules and text record     *)
                                  (*        structures           *)
ststage = record
  problemtype : integer;
  timefrom    : integer;
  timeto      : integer;
  ndstacode   : string[3]
end;

ndstage = record
  acode     : string[3];
  samelist  : array[1..10] of string[3];
  opplist   : array[1..10] of string[3]
end;

currentrule= record
  alistsame : array[1..10] of string[3];
  alistopp :  array[1..10] of string[3];
end;

injtime  =  record
  t1 : array[1..2] of integer;
  t2 : array[1..2] of integer;
  lt : array[1..2] of integer;
end ;

str2=string[2];
str3=string[3];
```

```
  notes   = record
    nod     : tim;
    extras : array[1..4] of string[70];
  end;

  ststagefile    = file of ststage;
  ndstagefile    = file of ndstage;
  currentrfile   = file of currentrule;
  injectionfile = file of injtime;

  cdatefile      = file of cdate;
  bfile          = file of blood;
  ufile          = file of urine;
  dfile          = file of diet;
  ifile          = file of insulin;
  exfile         = file of exercise;
  hyfile         = file of hypos;
  hefile         = file of health;
  emfile         = file of emotion;
  hofile         = file of holidays;
  nfile          = file of notes;
  btrecs         = file of btrec;
  randomfile     = file of randomrec;

  strtok    = string[3];
  max_menu = array[1..11] of string[19];

  arr5      = array[1..5]of integer;
  arr4      = array[1..4]of real;
  arri4     = array[1..4]of integer;
  arr3      = array[1..3]of real;

  randomrec = record
    ltext:string
  end;


var erfile          : randomfile;
    errec           : randomrec;
    retck           : boolean;
    mwnus,
    option_chosen,
    z,x,
    xc1,
    xc2,
    yc1,
    yc2             : integer;
    ch,
    f1:char;
    adtext,
    geninfo,
    scron,
    clintext,
    menuf,
    helpfile ,
    inscreens,
    ptype     : text;
    options,
    menu_array    : max_menu;
```

```
                                (*     file declararions        *)
cdatef    : cdatefile;
exnotes   : exnotesf;
texts     ,
errfile   : textsf;
diabdets  : diabdetsf;
insdets   : insulinf;
stage1    : ststagefile;
stage2    : ndstagefile;
currentr  : currentrfile;
itimes    : injectionfile;
tbt,
backtrack: btrecs;
btr       : btrec;
stadvice  ,
ndadvice  : text;
clinic_d  : cdate;
bloodf    : bfile;
urinef    : ufile;
dietf     : dfile;
insuf     : ifile;
exerf     : exfile;
hypof     : hyfile;
healf     : hefile;
emotf     : emfile;
holsf     : hofile;
notesf    : nfile;
tempb     : bfile;
tempu     : ufile;
tempd     : dfile;
tempi     : ifile;
tempe     : exfile;
temphy    : hyfile;
temphe    : hefile;
tempem    : emfile;
tempho    : hofile;
tempn     : nfile;
blcheck   : bfile;
utcheck   : ufile;
blt       : bfile;
urt       : ufile;
hycheck   ,
hrt       : hyfile;

urecl     ,
urec      : urine;
brecl     ,
brec      : blood;
drec      : diet;
inrec     : insulin;
exrec     : exercise;
hyrec     : hypos;
herec     : health;
emrec     : emotion;
horec     : holidays;
norec     : notes;

                                (* record declarations           *)
st        : ststage;
nd        : ndstage;
cr        : currentrule;
```

```
    extran     : notes;
    extext     ; dialog;
    dets       : details;
    insul      : regime;

                                    (*          variables          *)
    time       ,
    time1      ,
    extratext,
    a,
    time       ,
    linec      ,
    reply      ,
    ch1        ,
    ch2        : character;
    uok        ,
    qok        ,
    finished : boolean;
    attribute: attributesType;

    linec      ,
    newq       ,
     treatmentcode :integer;

    injt       : injtime;

    newt       : string;

    tok3       : str3;

{$I-}
procedure initialise;
procedure errmess(xpos,ypos,errno,x1,y1,x2,y2,origx,origy:integer);
procedure finddate(db:tim;dd:tim;var dfound:boolean);
procedure setwindow(x1,y1,x2,y2:integer);
procedure scrout(token:str3;var filename:text);
procedure putonbacktrack(probt:integer;stime:boolean;token:str3;
                         var filename:text);
procedure setscreenup;
procedure sr_scr(sorr:boolean);
procedure save_screen(top_x,top_y,bottom_x,bottom_y:integer;
                      var screen_no:integer);
procedure restore_screen(screen_no:integer);
procedure messout;
procedure blankmess(bx1,by1,x1,y1,x2,y2,stx,sty:integer);
procedure writetime(x,y,hr,min:integer);
procedure page_mess(y:integer);
procedure page_control(maxormin:integer;back_p:boolean;var h_c:str3);
procedure scrtxt(max,min:integer;h_c:str3;var filen:text);
procedure hhelp(hmax,hmin:integer;hcode:str3;a1,b1,a2,b2:integer;
                xcoord,ycoord:integer);
procedure getkey(hma,hmi:integer;hc:str3;a1,b1,a2,b2,xc,yc:integer;
                 var ch:char);
procedure disp_ret;
procedure get_return(hmax,hmin:integer;acode:str3);
procedure scrandret(hmax,hmin:integer;h_c:str3;x1,y1,x2,y2:integer;
                    scrcode:strr3;var filen:text);
procedure rec_mon_blood(bloodrec:blood);
procedure rec_mon_urine(urinerec:urine);
procedure rec_mon_hypo(hyposrec:hypos);
procedure tot_hypos;
```

```
procedure monitor_tests(var bamhigh,uamhigh,btothigh,
                              utothigh:integer);
procedure advice_promt;
procedure advicechart;
procedure yesornocheck(hmax,hmin:integer;hc:str3;x1,y1,x2,y2,origx,
                         origy:integer;var yes:boolean);
procedure yesnoesccheck(hmax,hmin:integer;hc:str3;x1,y1,x2,y2,origx,
                          origy:integer;var yes,escout:boolean);
procedure ampmcheck(hmax,hmin:integer;hc:str3;x1,y1,x2,y2,origx,
                      origy:integer;var pm:boolean);
procedure readtime(hmax,hmin:integer;hc:str3;x1,y1,x2,y2,stx,
                     sty:integer;var th,tm:str2;
                   var pm:boolean;var hrs,mins:integer);
procedure chkhr24(var hr24:integer);
procedure gettimespan(var acode2:str3;pt:integer;hrs,mins:integer);
procedure stage1or2(var stime,esc:boolean);
procedure askq(ac:str3;a1,b1,a2,b2,ox,oy:integer;var yes,esc:boolean);
procedure identifyproblem(var pt:integer;var action_code:str3;
                            var ains,escout:boolean);
procedure setupcrfile(advice_token:str3);
procedure puutadviceonbtrack(probtyp:integer;stimes:boolean;
                              advice_token:str3;var filen:text);
procedure establishoutcome(var yes,esc:boolean);
procedure take_advice(var advice_taken:boolean);
procedure findnextcode(sameprob:boolean;var advice_token:str3);
procedure displaybt;
procedure giveadvice;
procedure advice;
```

```
implementation

{$I-}
procedure initialise;
begin
  assign(texts,'b:textd.txt');
  assign(adtext,'b:estext.txt');
  assign(diabdets,'b:diadets.txt');
  assign(insdets,'b:diains.txt');
  assign(menuf,'b::menuf.dat');
  assign(erfile,'b:errandf.dat');
  assign(inscreens,'b:inscreen.dat');
  assign(exnotes,'b:exnotes.dat');
  assign(helpfile,'b:helpf.txt');
  assign(bloodf,'b:bloodf.dat');
  assign(urinef,'b:urinef.dat');
  assign(dietf,'b:dietf.dat');
  assign(exerf,'b:exerf.dat');
  assign(hypof,'b:hypof.dat');
  assign(healf,'b:health.dat');
  assign(emotf,'b:emotf.dat');
  assign(holsf,'b:holsf.dat');
  assign(notesf,'b:dnotes.dat');
  assign(tempb,'b:tempb.dat');
  assign(tempd,'b:tempd.dat');
  assign(tempu,'b:tempu.dat');
  assign(cdatef,'b:clinicd.dat');
  assign(geninfo,'b:geninfo.txt');
  assign(tbt,'b:tbt.dat');
  assign(helpfile,'b:helpf.txt');
  assign(cdatef,'b:clinicd.dat');
  assign(stage1,'b:stage1.dat');
  assign(stadvice,'b:stadvice.txt');
  assign(stage2,'b:stage2.dat');
  assign(ndadvice,'b:ndadvice.txt');
  assign(clintext,'b:clintext.txt');
  assign(blcheck,'b:blcheck.dat');
  assign(utcheck,'b:utcheck.dat');
  assign(blt,'b:blt.dat');
  assign(urt,'b:urt.dat');
  assign(hycheck,'b:hycheck.dat');
  assign(hrt,'b:hrt.dat');
  assign(scron,'b:scron.txt');
  assign(ptype,'b:ptype.txt');
end;

procedure finddate(db:tim;dd:tim;var dfound:boolean);
var esame,x:integer;
begin
  dfound:=false;
  esame:=0;
  for x:=1 to 3 do
  begin
    if db[x]=dd[x] then esame:=esame+1
  end;
  if esame=3 then dfound:=true
end;
```

```
(**************************************************************)
(*                                                            *)
(*                 SCREEN HANDLING MODULE                     *)
(*                                                            *)
(**************************************************************)

procedure errmess(xpos,ypos,errno,x1,y1,x2,y2,origx,origy
                                                  : integer);
var x:integer;
begin
  reset(erfile);
  seek(erfile,errno);
  x:=1;
  window(2,8,79,23);
  read(erfile,errec);
  textcolor(Ø);
  textbackground(7);
  while (x<8Ø) and (errec.ltext[x]<>'"') do
  begin
    gotoxy(xpos+x,ypos);
    write(errec.ltext[x]);
    x:=x+1
  end;
  textcolor(15);
  textbackground(Ø);
  window(x1,y1,x2,y2);
  gotoxy(origx,origy)
end;


                               (*  set up an outlined window   *)
procedure setwindow(x1,y1,x2,y2:integer);
const upleftcorner    = £2Ø1;
      horzbar         = £2Ø5;
      uprightcorner   = £187;
      vertbar         = £186;
      lowleftcorner   = £2ØØ;
      lowrightcorner  = £188;
var i:integer;
begin
  window(x1-1,y1-1,x2+1,y2+1);
  window(1,1,8Ø,25);
  gotoxy(x1-1,y1-1);
  write(upleftcorner);
  for i:=x1 to x2 do write(horzebar);
  write(uprightcorner);
  for i:=y1 to y2 do
  begin
    gotoxy(x1-1,i);write(vertbar);
    gotoxy(x2+1,i);write(vertbar)
  end;
  gotoxy(x1-1,y2+1);
  write(lowleftcorner);
  for i:=x1 to x2 do write(horzbar);
  write(lowrightcorner);
  window(x1,y1,x2,y2)
end;
```

```
                                   (*   output a screen of text   *)
procedure scrout(token:str3;var filename:text);
var tokfound:boolean;
    ch:char;
    same,x:integer;
    posstoken:string[3];
begin
  tokfound:=false;
  ch:=' ';
  reset(filename);
  while not(eof(filename)) and not(tokfound) do
  begin
    if (ch='"') and (not(tokfound)) then
    begin
      same:=Ø;
      for x:=1 to 3 do
      begin
        read(filename,posstoken[x]);
        if posstoken[x]=token[x] then same:=same+1
      end;
      read(filename,ch);
      if same=3 then
      begin
        tokfound:=true;
        repeat
          read(filename,ch);
          if ch<>'"' then write(ch)
        until (ch='"') or (eof(filename))
      end
    end
    else
      read(filename,ch)
  end;
  close(filename)
end;
                                   (* put advice on backtrack file  *)

procedure putonbacktrack(probt:integer; stime:boolean;token:str3;
                          var filename:text);
var tokfound:boolean;
    ch:char;
    s,same,x:integer;
    posstoken:string[3];
    origp:string[55];
    ex :word;
begin
  tokfound:=false;
  ch:=' ';
  for s:=1 to 32Ø do btr.bta[s]:=' ';
  reset(filename);
  rewrite(tbt);
  if not(stime) then
  begin
    reset(backtrack);
    repeat
      if not eof(backtrack) then
      begin
        read(backtrack,btr);
        write(tbt,btr)
      end
    until eof(backtrack);
```

```
  end
  else
  begin
    getdate(btr.btd[3],btr.btd[2],btr.btd[1],ex);
    reset(messagef);
    if probt=Ø then
      seek(messagef,1Ø)
    else
      seek(messagef,11);
    read(messagef,messg);
    write(messg.mr);
    for s:=1 to 55 do
    btr.bta[s]:=origp[s];
    write(tbt,btr)
  end;
  while not(eof(filename)) and not(tokfound) do
  begin
    if (ch='"') and (not(tokfound)) then
    begin
      same:=Ø;
      for x:=1 to 3 do
      begin
        read(filename,posstoken[x]);
        if posstoken[x]=token[x] then same:=same+1
      end;
      read(filename,ch);
      if same=3 then
      begin
        s:=1;
        tokfound:=true;
        repeat
          if not eof(filename) then read(filename,ch);
          if ch<>'"' then
          begin
            btr.bta[s]:=ch;
            s:=s+1
          end
        until (s=32Ø) or (ch='"') or (eof(filename));
        btr.bta[s]:='"'
      end
    end
    else
      read(filename,ch)
  end;
  getdate(btr.btd[3],btr.btd[2],btr.btd[1],ex);
  write(tbt,btr);
  reset(tbt);
  rewrite(backtrack);
  repeat
    if not eof(tbt) then
    begin
      read(tbt,btr);
      write(backtrack,btr)
    end
  until eof(tbt);
  close(tbt);
  close(backtrack);
  close(filename);
end;
```

```
                                (*    set the screen up with    *)
                                (*       heading and date        *)
procedure setscreenup;
var dy,dm,dd,dw:word;
begin
  clrscr;
  setwindow(2,2,79,5);
  scrout('Ø2Ø',menuf);
  getdate(dy,dm,dd,dw);
  gotoxy(69,2);
  writeln(dd,'/',dm,'/',dy);
  setwindow(2,8,79,23);
end;

                                (*   save and refresh screen    *)
procedure sr_scr(sorr:boolean);
var row, col    : byte;
    buffer      : array[1..1265] of char;

    procedure readit(startrow,startcol :byte);
    var row, col :byte;
        i:integer;
    begin
      for i:= 1 to 1265 do buffer[i]:= 32;
      i:= Ø;
      for row:= startrow to startrow + 15 do
        for col:= startcol to startCol + 76 do
        begin
          i:= i + 1;
          buffer[i]:= charat(row,col);
        end;
        clrscr;
    end;

    procedure writeit(startrow, startcol :byte);
    var row, col    :byte;
        i:integer;
    begin
      clrscr;
      i:= Ø;
      for row:= startrow to startrow + 14 do
        for col:= startcol to startcol + 76 do
        begin
          i:= i + 1;
          cursorto(row,col);
          write(chr(buffer[i]));
        end;
    end;



    procedure stry(sr:boolean);
    begin
      window(2,8,79,23);
      if sr=true then
        readit(8,2)
      else
        writeit(8,2);
    end;
```

```
begin
  with attribute do
  begin
    foreground:= white;
    background:= black;
    bold:= off;
    blink:= off;
  end;
  setdefaultattributes(attribute);
  withattribute do
  begin
    setforeground(foreground,bold);
    setbackground(background);
  end;
  stry(sorr);
  setforeground(white,Off);
  setBackground(black);
end;


                                 (*    write help indicator      *)
procedure messout;
begin
  setwindow(32,22,46,22);
  reset(messagef,1);
  read(messagef,messg);
  write(messge,mr)
end;


                                 (*      write blank line        *)
procedure blankmess(bx1,by1,x1,y1,x2,y2,stx,sty:integer);
begin
  window(2,8,79,23);
  gotoxy(bx1,by1);
  write('                            ');
  window(x1,y1,x2,y2);
  gotoxy(stx,sty)
end;

                                 (* read system time and write   *)
procedure writetime(x,y,hr,min:integer);
begin
  gotoxy(x,y);
  if (hr<1Ø) or ((hr>12)and(hr<22)) then write('Ø');
  if (hr=24) or (hr>12) then
    write(hr-12)
  else
    write(hr);
  gotoxy(x+3,y);
  if (min<1Ø) and (min<>Ø) then write('Ø');
  write(min);
  if min=Ø then write('Ø');
  gotoxy(x+7,y);
  if (hr<12) or (hr=24) then
    write('a')
  else
    write('p')
end;
```

```
(**************************************************************)
(*                                                            *)
(*           HELP AND GENERAL INFORMATION   MODULE            *)
(*                                                            *)
(**************************************************************)

                                (*   page message for user     *)
procedure page_mess(y:integer);
begin
  textcolor(Ø);
  textbackground(7);
  gotoxy(13,y);
  reset(messagef);
  seek(messagef,5);
  read(messagef,messg);
  write(messg,mr);
  gotoxy(34,y);
  write(chr(26));
  gotoxy(54,y);
  write(chr(27));
  textcolor(15);
  textbackground(Ø);
  gotoxy(67,y)
end;

                                (* get a page of text from a   *)
                                (* text file and page forward  *)
                                (* or back                     *)
procedure page_control(maxormin:integer;back_p:boolean;
                                          var h_c:str3);
var help_code:integer;
begin
  help_code:=((ord(h_c[1])-48)*1ØØ)
            +((ord(h_c[2])-48)*1Ø)
             +(ord(h_c[3])-48) ;
  if back_p then
  begin
    help_code:=help_code-1;
    if help_code<maxormin then help_code:=help_code+1
  end
  else
  begin
    help_code:=help_code+1;
    if help_code>maxormin then help_code:=help_code-1
  end;
  h_c[1]:=chr((help_code div 1ØØ)+48);
  h_c[2]:=chr((help_code div 1Ø)+48);
  h_c[3]:=chr((help_code mod 1Ø)+48);
end;

                                (* collect a page of text from *)
                                (* a text file and output to   *)
                                (* the current winndow          *)
procedure scrtxt(max,min:integer;h_c:str3;var filen:text);
var ch:char;    x:integer;
    back_p,back_to_sys,val_h_key:boolean;
begin
  back_to_sys:=false;
  clrscr;
  for x:=1 to 3 do write(h_c[x]);
```

```
  repeat
    back_p:=false;
    clrscr;
    scrout(h_c,filen);
    page_mess(15);
    repeat
      val_h_key:=true;
      repeat
      until keypressed;
      ch:=readkey;
      if ch=£0 then ch:=readkey;
      case ord(ch) of
        27 : back_to_sys:=true;
        77 : page_control(max,back_p,h_c);
        75 : begin
               back_p:=true;
               page_control(min,back_p,h_c)
             end;
        else
          val_h_key:=false
      end;
    until val_h_key
  until back_to_sys
end;
                                (* help control :             *)
                                (*   -  save current window   *)
                                (*   -  clear window          *)
                                (*   -  transfer to page control *)
                                (*   -  refresh window        *)

procedure hhelp(hmax,hmin:integer;hcode:str3;
                                    a1,b1,a2,b2:integer;
                                    xcoord,ycoord:integer);
var ax1,ay2:integer;
begin
  sr_scr(true);
  scrtxt(hmax,hmin,hcode,helpfile);
  clrscr;
  sr_scr(false);
  window(30,21,78,22);
  clrscr;
  messout;
  window(a1,b1,a2,b2);
  gotoxy(xcoord,ycoord)
end;

                                 (* wait until a key is pressed *)
procedure getkey(hma,hmi:integer;hc:str3;
                                   a1,b1,a2,b2,xc,yc:integer;
                                   var ch:char);
begin
  repeat
    repeat
    until keypressed;
    ch:=readkey;
    if ch=£0 then ch:=readkey;
    if ord(ch)=59 then hhelp(hma,hmi,hc,a1,b1,a2,b2,xc,yc)
  until ord(ch)<>59
end;
```

```
                                 (*display 'press return' message*)
procedure disp_ret;
begin
  window(2,8,79,23);
  textcolor(Ø);
  textbackground(7);
  gotoxy(25,13);
  write(' press return to continue ');
  textcolor(15);
  textbackground(Ø);
  gotoxy(5Ø,13);
end;

                                 (*wait until the user presses    *)
                                 (*          return               *)
procedure get_return(hmax,hmin:integer;acode:str3);
var ch:char;
begin
  repeat
    disp_ret;
    repeat
    until keypressed;
    ch:=readkey;
    if ch=£Ø then ch:=readkey;
    if ord(ch)=59 then hhelp(hmax,hmin,acode,2,8,79,23,5Ø,13);
  until ord(ch)=13
end;

                                 (*   write screen and wait      *)
                                 (*    for return                *)
procedure scrandret(hmax,hmin:integer;h_c:str3;
                    x1,y1,x2,y2:integer;
                    scrcode:str3;var filen:text);
var ch:char;
begin
  window(x1,y1,x2,y2);
  scrout(scrcode,filen);
  messout;
  window(x1,y1,x2,y2);
   repeat
    disp_ret;
    repeat
    until keypressed;
    ch:=readkey;
    if ch=£Ø then ch:=readkey;
    if ord(ch)=59 then
    begin
      if (x1=2) and (y1=2) then
      begin
        window(1,1,8Ø,24);
        setscreenup
      end;
      window(2,8,79,23);
      scrtxt(hmax,hmin,h_c,helpfile);
      setwindow(x1,y1,x2,y2);
      scrout(scrcode,filen);
      messout;
      window(x1,y1,x2,y2);
    end
  until ord(ch)=13;
end;
```

```
(*****************************************************************)
(*                                                               *)
(*                         ADVICE MODULE                         *)
(*                                                               *)
(*****************************************************************)

                                (* calculate avarage test      *)
                                (* results for prevoius four   *)
                                (* days                        *)
procedure rec_mon_blood(bloodrec:blood);
var s,x:integer;
    blrec:blood;
    foundr:boolean;
    d1,d2,d3,d4:word;
begin
  foundr:=false;
  reset(blcheck);
  for x:=1 to 4 do
  begin
    getdate(d1,d2,d3,d4);
    read(blcheck,blrec);
    if (blrec.bd[1]=d1) and (blrec.bd[2]=d2) and
                        (blrrec.bd[3]=d3) then
    begin
      foundr:=true;
      s:=x
    end
  end;
  reset(blcheck);
  rewrite(blt);
  if foundr=true then
  begin
    if s=1 then write(blt,bloodrec)
    else
    begin
      for x:=1 to s-1 do
      begin
        read(blcheck,blrec);
        write(blt,blrec)
      end;
      write(blt,bloodrec);
      if s<>4 then
        for x:=s+1 to 4 do
        begin
          read(blcheck,blrec);
          write(blt,blrec)
        end
      else
      begin
        reset(blt);rewrite(blcheck);
        for x:=1 to 4 do
        begin
          read(blt,blrec);
          write(blcheck,blrec)
        end
      end
    end
  end
  else
```

```
  begin
    read(blcheck,blrec);
    for x:=1 to 3 do
    begin
      read(blcheck,blrec);
      write(blt,blrec)
    end;
    reset(blt);
    rewrite(blcheck);
    for x:=1 to 3 do
    begin
      read(blt,blrec);
      write(blcheck,blrec);
    end;
    write(blcheck,bloodrec)
  end
end;

procedure rec_mon_urine(urinerec:urine);
var x:integer;
    urirec:urine;
begin
  reset(utcheck);
  rewrite(urt);
  read(utcheck,urirec);
  for x:=1 to 3 do
  begin
    read(utcheck,urirec);
    write(urt,urirec)
  end;
  reset(urt);
  rewrite(utcheck);
  for x:=1 to 3 do
  begin
    read(urt,urirec);
    write(utcheck,urirec);
  end;
  write(utcheck,urinerec)
end;
                                  (* cheack the number of hypos   *)
                                  (* for last four days           *)
procedure rec_mon_hyypo(hyposrec:hypos);
var y,x:integer;
    hypor:hypos;
    foundr:boolean;
    d1,d2,d3,d4:word;
begin
  foundr:=false;
  reset(hycheck);
  getdate(d1,d2,d3,d4);
  for x:=1 to 4 do read(hycheck,hypor);
  if ((hypor.hyd[1]=d1) and (hypor.hyd[2]=d2)
                        and (hypor.hyd[3]=d3)) then foundr:=true;
  reset(hycheck);
  rewrite(hrt);
  if foundr then
  begin
```

```
    for x:=1 to 3 do
    begin
      read(hycheck,hypor);
      write(hrt,hypor);
    end;
    write(hrt,hyposrec)
  end
  else
  begin
    read(hycheck,hypor);
    for x:=1 to 3 do
    begin
      read(hycheck,hypor);
      write(hrt,hypor);
    end;
    write(hrt,hyposrec)
  end;
  reset(hrt);
  rewrite(hycheck);
  for x:=1 to 4 do
  begin
    read(hrt,hypor);
    write(hycheck,hypor);
  end;
  close(hycheck);
  close(hrt)
end;

procedure tot_hypos;
var x,y,tothyps:integer;
    hypor:hypos;
    hypod:array[1..4] of integer;
begin
  reset(hycheck);
  tothyps:=Ø;
  for x:=1 to 4 do hypod[x]:=Ø;
  for x:=1 to 4 do
  begin
    read(hycheck,hypor);
    for y:=1 to 6 do
    if (hypor.ht[1,y]<>Ø) then
    begin
      tothyps:=tothyps+1;
      hypod[x]:=hypod[x]+1
    end;
  end;
  reset(messagef);
  if (tothyps>=4) and (hypod[4]>Ø) then
  begin
    gotoxy(6,4);
    writeln;
    seek(messagef,2Ø);
  end
  else
    seek(messagef,21');
  read(messagef,messg);
  write(messg,mr);
end;
```

```
procedure monitor_tests(var bamhigh,uamhigh,btotthigh,
                                                      utothigh:integer);
var x,y,t :integer;
begin
  window(2,8,79,23);
  reset(blcheck); reset(utcheck);
  bamhigh:=Ø;
  btothigh:=Ø;
  uamhigh:=Ø;
  utothigh:=Ø;
  for x:=1 to 4 do
  begin
    if not eof(blcheck) then
    begin
      read(blcheck,brec);
      for y:=1 to 6 do
      begin
        if (brec.bth[y]<8) and (brec.br[y]>9) then
             bamhigh:=bamhigh+1;
        if brec.br[y]>9 then btothigh:=btothigh+1
      end;
      read(utcheck,urec);
      if ((urec.ur[1]>1)and not(urec.ur[1]=9)) then
      begin
        uamhigh:=uamhigh+1;
        utothigh:=utothigh+1
      end;
      for y:=2 to 4 do
        if (urec.ur[y]>1) and (urec.ur[y]<>9) then
          utothigh:=utothigh+1;
    end;
    writeln
  end;
end;

procedure advice_promt;
var bamhigh,
    uamhigh,
    btothigh,
    utothigh,
    x,y:integer;
    z:word;
begin
  clrscr;
  scrout('1ØØ',inscreens);
  messout;
  monitor_tests(bamhigh,uamhigh,btothigh,utothigh);
  window(2,8,79,23);
  gotoxy(2,12);
  gotoxy(6,6);
  reset(messagef,messg);
  if bamhigh>2 then seek(messagef,22)
  else
  begin
    gotoxy(6,6);
    if uamhigh>2 then seek(messagef,23)
    else
    begin
       gotoxy(6,6);
       if utothigh>4 then seek(messagef,24)
       else
```

```
      begin
        gotoxy(6,6);
        if btothigh>4 then seek(messagef,25)
        else
        begin
          gotoxy(6,6);
          seek(messagef,26)
       end
     end
   end
 end;
 read(messagef,messg);
 write(messg,mr);
 tot_hypos;
 get_return(37,34,'Ø35')
end;
```

```
(*                                                                  *)
(*                       problem advice                             *)
(*                                                                  *)

                              (*     write action chart             *)
procedure advicechart;
var ch:char;
    val,reg,x:integer;
    actch:text;
    s1,s2,sascr:str3;
    backtosys:boolean;
begin
  assign(actch,'b:actch.txt');
  reset(scron);
  for x:=1 to 2 do read(scron,ch);
  if ch='y' then
  begin
    scrandret(30,27,'027',2,8,79,23,'903',actch);
    scrandret(30,27,'027',2,8,79,23,'904',actch);
  end;
  setwindow(2,2,79,23);
  val:=2;
  reg:=1;
  case val of
    2: case reg of
         1:begin       (* 2 inj 1 mixed *)
             s1:='905';
             s2:='906'
           end;
         2:begin       (* 2 inj 2 mixed *)
             s1:='907';
             s2:='908'
           end;
         3: begin      (* 2 inj ready mixed *)
             s1:='909';
             s2:='910'
           end;
       end;
    4: begin               (* 4 inj ready mixed *)
         s1:='907';
         s2:='908'
       end;
  end;
  backtosys:=false;
  setwindow(2,2,79,23);
  clrscr;
  sascr:=s1;
  scrout(s1,actch);
  repeat
    messout;
    window(2,2,79,23);
    page_mess(19);
    repeat
    until keypressed;
    ch:=readkey;
    if ch=£0 then ch:=readkey;
    case ord(ch) of
      27: backtosys:=true;
```

```
      75: begin
            clrscr;
            scrout(s1,actch);
            sascr:=s1
          end;
      77: begin
            clrscr;
            scrout(s2,actch);
            sascr:=s2
          end;
      59: begin
            window(1,1,80,24);
            clrscr;
            setscreenup;
            scrtxt(30,27,'027',helpfile);
            window(1,1,80,24);
            clrscr;
            setwindow(2,2,79,23);
            messout;
            window(2,2,79,23);
            scrout(sascr,actch)
          end
      else
      begin
      end
    end
  until backtosys=true;
  window(1,1,80,24);
  clrscr;
  setscreenup
end;
                                  (*       problem advice        *)

procedure yesornocheck(hmax,hmin:integer;hc:str3;x1,y1,x2,y2,
                        origx,origy:integer;var yes:boolean);
var  ch1,ch2 : char;
     yncheck,
     ycheck:boolean;
begin
  yes:=false;
  repeat
    getkey(hmax,hmin,hc,x1,y1,x2,y2,origx,origy,ch1);
    blankmess(25,13,x1,y1,x2,y2,origx,origy);
    if not((ord(ch1)=121) or (ord(ch1)=89) or (ord(ch1)=78)
        or (ord(ch1)=110)) then
      errmess(26,13,2,x1,y1,x2,y2,origx,origy)
     else
    begin
      gotoxy(origx,origy);
      write(chr(ord(ch1)))
    end
  until (ord(ch1)=121) or (ord(ch1)=89) or (ord(ch1)=78)
                        or (ord(ch1)=110);
  if (ord(ch1)=89) or (ord(ch1)=121) then yes:=true
end;
```

```
procedure yesnoesccheck(hmax,hmin:integer;hc:str3;x1,y1,x2,y2,
                        origx,origy:integer;
                        var yes,escout:boolean);
var ch1,ch2 : char;
    yncheck,
    ycheck:boolean;
begin
  yes:=false;
  repeat
    getkey(hmax,hmin,hc,x1,y1,x2,y2,origx,origy,ch1);
    blankmess(25,13,x1,y1,x2,y2,origx,origy);
    if ord(ch1)=27 then
      escout:=true
    else
      if not((ord(ch1)=121) or (ord(ch1)=89) or (ord(ch1)=78)
                              or (ord(ch1)=110)) then
        errmess(26,13,2,x1,y1,x2,y2,origx,origy)
      else
      begin
        gotoxy(origx,origy);
        write(chr(ord(ch1)))
      end
  until (escout=true) or (ord(ch1)=121) or (ord(ch1)=89)
                        or (ord(ch1)=78) or (ord(ch1)=110);
  if (ord(ch1)=89) or (ord(ch1)=121) then yes:=true
end;

procedure ampmcheck(hmax,hmin:integer;hc:str3;x1,y1,x2,y2,
                    origx,origy:integer;var pm:boolean);
var ch1,ch2 : char;
    yespm,
    pmcheck:boolean;
begin
  pm:=false;
   pmcheck:=false;
  gotoxy(origx,origy);
  repeat
    getkey(hmax,hmin,hc,x1,y1,x2,y2,origx,origy,ch1);
    write(chr(ord(ch1)));
    blankmess(25,13,x1,y1,x2,y2,origx,origy);
    if (ord(ch1)<>65)and(ord(ch1)<>80)and(ord(ch1)<>97)
                                      and(ord(ch1)<>112) then
      errmess(26,13,11,x1,y1,x2,y2,origx,origy)
  until (ord(ch1)=65) or (ord(ch1)=80) or (ord(ch1)=97)
                                       or (ord(ch1)=112);
  if (ord(ch1)=80) or (ord(ch1)=112) then pm:=true
end;

procedure readtime(hmax,hmin:integer;hc:str3;
                   x1,y1,x2,y2,stx,sty:integer;var th,tm:str2;
                   var pm:boolean;var hrs,mins:integer);
var getout,timeck:boolean;
    ch:char;
begin
  getout:=false;
  retck:=false;
  repeat
    timeck:=true;
    getkey(hmax,hmin,hc,x1,y1,x2,y2,stx,sty,th[1]);
    blankmess(26,13,x1,y1,x2,y2,stx,sty);
```

```
    if (ord(th[1])=48) or (ord(th[1])=49)  then
    begin
      write(th[1]);
      getkey(hmax,hmin,hc,x1,y1,x2,y2,stx+1,sty,th[2]);
      write(th[2],'.');
      if ((ord(th[2])>47) and (ord(th[2])<58))
          and not(((ord(th[2])=48)and(ord(th[1])=48)))then
      begin
        getkey(hmax,hmin,hc,x1,y1,x2,y2,stx+3,sty,tm[1]);
        write(chr(ord(tm[1])));
        if (ord(tm[1])>47) and (ord(tm[1])<55) then
        begin
          getkey(hmax,hmin,hc,x1,y1,x2,y2,stx+4,sty,tm[2]);
          if (ord(tm[2]])>47) and (ord(tm[2])<58) then
          begin
            write(chr(ord(tm[2])));
            if (ord(tm[1])=54) and (ord(tm[2])<>48) then
              timeck:=false
          end
          else
            timeck:=false
        end
        else
          timeck := false
      end
      else
        timeck := false
    end
    else
      timeck:=false;
    if not timeck then errmess(23,13,7,x1,y1,x2,y2,stx,sty);
    if timeck then
    begin
      gotoxy(stx+5,sty);
      ampmcheck(hmax,hmin,hc,x1,y1,x2,y2,stx+7,sty,pm);
      hrs:=((ord(th[1])-48)*10)+((ord(th[2])-48));
      mins:=((ord(tm[1])-48)*10)+((ord(tm[2])-48));
      if hrs>12 then
      begin
        timeckk:=false;
        errmess(23,13,7,x1,y1,x2,y2,stx,sty);
      end
      else
      begin
        if (tm[1]='0') and (tm[2]='0') then mins:=0;
        if pm and (hrs<>12) then hrs:=hrs+12;
        if not(pm) and (hrs=12) then hrs:=24
      end
    end
  until (timeck=true);
end;


procedure chkhr24(var hr24:integer);
begin
  if hr24>24 then hr24:=hr24-24
end;
```

```
procedure gettimespan(var acode2:str3;pt:integer;hrs,mins:integer);
var c,x,r,tfhrs,tfmins,tthrs,ttmins:integer;
    foundac:boolean;
begin
  for x:=1 to 3 do acode2[x]:=' ';
  foundac:=false;
  repeat
    if not eof(stage1) then read(stage1,st);
    case st.timefrom of
      Ø : begin
            tfhrs  := injt.t1[1]+1;
            tfmins := injt.t1[2];
          end;
      1 : begin
            tfhrs  := injt.lt[1];
            tfmins := injt.lt[2];
          end;
      2 : begin
            tfhrs  := injt.t2[1]+1;
            tfmins := injt.t2[2]
          end;
      3 : begin
            tfhrs  := injt.t2[1]+5;
            tfmins := injt.t2[2];
          end
    end;
    chkhr24(tfhrs);
    case st.timeto of
      Ø : begin
            tthrs  := injt.t1[1]+1;
            ttmins := injt.t1[2];
          end;
      1 : begin
            tthrs  := injt.lt[1];
             ttmins := injt.lt[2];
          end;
      2  : begin
             tthrs  := injt.t2[1]+1;
             ttmins := injt .t2[2];
           end;
      3  : begin
             tthrs  := injt.t2[1]+5;
             ttmins := injt.t2[2];
           end;
    end;
    chkhr24(tthrs);
    if ((hrs>tfhrs)and(hrs<tthrs) and (pt=st.problemtype)) then
    begin
      for x:=1 to 3 do acode2[x]:=st.ndstacode[x];
      foundac:=true
    end;
    if ((hrs=tfhrs)and(mins>tfmins) and (pt=st.problemtype)) then
    begin
      for x:=1 to 3 do acode2[x]:=st.ndstacode[x];
      foundac:=true
    end;
    if ((hrs=tthrs)and(mins<ttmins) and (pt=st.problemtype)) then
    begin
      for x:= 1 to 3 do acode2[x]:=st.ndstacode[x];
      foundac:=true
    end;
```

```
    if ((tthrs<tfhrs)and(hrs>12) and
       ((hrs<24)or(hrs=24)) and (pt=st.problemtype)) then
    begin
      for x:= 1 to 3 do acode2[x]:=st.ndstacode[x];
      foundac:=true
    end;
    if ((tthrs<tfhrs) and (hrs<12) and (hrs>Ø) and
              (hrs<tthrs) and (pt=st.problemtype) ) then
    begin
      for x:=1 to 3 do acode2[x]:=st.ndstacode[x];
      foundac:=true
    end;
  until eof(stage1) or foundac;
end;

procedure stage1or2(var stime,esc:boolean);
var yes:boolean;
begin
  scrout('Ø51',inscreens);
  messout;
  window(2,8,79,23);
  stime:=false;
  yes:=false;
  gotoxy(45,7);
  yesnoesccheck(37,36,'Ø36',2,8,79,23,45,7,yes,esc);
  if not(esc) then
  begin
    if not(yes) then
    begin
      assign(stage1,'b:stage1.dat');
      assign(stadvice,'b:stadvice.txt');
      assign(stage2,'b:stage2.dat');
      stime:=true
    end
    else
      assign(ndadvice,'b:ndadvice.txt')
    assign(backtrack,'b:backtrack.dat');
    assign(currentr,'b:currentr.dat');
    assign(itimes,'b:injtim.dat')
  end
end;

procedure askq(ac:str3;a1,b1,a2,b2,ox,oy:integer;
                        var yes,esc:boolean);
begin
  clrscr;
  scrout(ac,adtext);
  gotoxy(ox,oy);
  yesnoesccheck(37,36,'Ø36',a1,b1,a2,b2,ox,oy,yes,esc)
end;

procedure identifyproblem(var pt:integer;var action_code:str3;
                          var ains,escout:boolean);
var yes,hypos,highs:boolean;
    x,h,m,hrs,mins:integer;
    th,tm:str2;
begin
  escout:=false;
  ains:=false;
  hypos:=false;
  highs:=false;
```

```
gotoxy(45,9);
window(3,11,78,19);
askq('Ø1Ø',3,11,78,19,52,4,yes,escout);
if yes and not(escout) then
begin
  hypos:=true;
  pt:=1;
  askq('Ø11',3,11,78,19,52,4,yes,escout);
  if yes and not(escout) then
  begin
    askq('Ø12',3,11,78,19,52,4,yes,escout);
    if yes and not(escout) then
    begin
      askq('Ø13',3,11,78,19,52,4,yes,escout);
      if yes=false and not(escout)  then
      begin
        askq('Ø14',3,11,78,19,52,4,yes,escout);
        if yes=false and not(escout)  then
        begin
          askq('Ø15',3,11,78,19,52,4,yes,escout);
          if yes=false and not(escout)  then
          begin
            clrscr;
            if not(escout) then scrout('161',adtext);
            ains:=true
          end
          else
          begin
             clrscr;
            if not(escout) then scrout('151',adtext)
          end
        end
        else
        begin
          clrscr;
          if not(escout) then scrout('141',adtext)
        end
      end
      else
      begin
        clrscr;
        if not(escout) then scrout('131',adtext)
      end
    end
    else
    begin
      clrscr;
      if not(escout) then scrout('121',adtext)
    end
  end
  else
  begin
    clrscr;
    if not(escout) then scrout('111',adtext)
  end;
 end
 else
```

```
begin
  pt:=Ø;
  highs:=true;
  askq('Ø2Ø',3,11,78,19,52,4,yes,escout);
  if yes and not(escout)  then
  begin
    askq('Ø21',3,11,78,19,52,4,yes,escout);
                if yes and not(escout)  then
    begin
      askq('Ø22',3,11,78,19,52,4,yes,escout);
      if yes and not(escout)  then
      begin
        askq('Ø23',3,11,78,19,52,4,yes,escout);
        if yes=false and not(escout) then
        begin
          askq('Ø24',3,11,78,19,52,4,yes,escout);
          if yes=false and not(escout) then
          begin
            askq('Ø25',3,11,78,19,52,4,yes,escout);
            if yes=false and not(escout) then
            begin
              clrscr;
              ains:=true;
              scrout('261',adtext)
            end
            else
            begin
              clrscr;
              if not(escout) then scrout('251',adtext)
            end
          end
          else
          begin
            clrscr;
            if not(escout) then scrout('241',adtext)
          end
        end
        else
        begin
          clrscr;;
          if not(escout) then scrout('231',adtext)
        end
      end
      else
      begin
        clrscr;
        if not(escout) then scrout('221',adtext)
      end
    end
    else
    begin
      clrscr;
      if not(escout) then scrout('211',adtext)
    end
  end
  else
  begin
    clrscr;
    if not(escout) then scrout('3ØØ',adtext)
  end
 end;
```

```
  get_return(37,36,'Ø36');
  if ains and not(escout) then
  begin
    rewrite(ptype);
    if highs then
      write(ptype,'1')
    else
      write(ptype,'2');
    close(ptype);
    window(3,11,78,2Ø);
    clrscr;
    scrout('Ø56',inscreens);
    gotoxy(37,3);
    readtime(37,36,'Ø36',3,11,78,19,37,3,th,tm,yes,hrs,mins);
    get_return(37,36,'Ø36');
    reset(itimes);
    reset(stage1);
    read(itimes,injt);
    gettimespan(action_code,pt,hrs,mins);
  end
end;

procedure displayadvice(advice_token:str3;sttime:boolean);
var x:integer;
begin
  clrscr;
  scrout('Ø52',inscreens);
  messout;
  window(2,8,79,23);
  gotoxy(4Ø,5);
  if sttime=true then
    scrout(advice_token,stadvice)
  else
    scrout(advice_token,ndadvice);
end;

procedure setupcrfile(advice_token:str3);
var x,y,z,same:integer;
begin
  reset(stage2);
  rewrite(currentr);
  repeat
    same:=Ø;
    if not eof(stagge2) then  read(stage2,nd);
    for x:=1 to 3 do
      if advice_token[x]=nd.acode[x] then same:=same+1;
    if same=3 then
    begin
      for x:=1 to 1Ø do
      begin
        for y:=1 to 3 do
        begin
          cr.alistsame[x,y]:=nd.samelist[x,y];
          cr.alistopp[x,y]:=nd.opplist[x,y];
        end
      end
    end
  until eof(stage2);
  write(currentr,cr);
  close(currentr)
end;
```

```
procedure putadviceonbtrack(probtyp:integer;stimes:boolean;
                              advice_token:str3;var filen:text);
var x:integer;
begin
  putonbacktrack(probtyp,stimes,advice_token,filen);
end;

procedure establishoutcome(var yes,esc:boolean);
var x:integer;
begin
  yes:=false;
  clrscr;
  scrout('Ø53',inscreens);
  messout;
  window(2,8,79,23);
  reset(backtrack);
  read(backtrack,btr);
  gotoxy(5,4);
  write('On  date - ',btr.btd[1],'/',btr.btd[2],'/',btr.btd[3]);
  gotoxy(1Ø,5);
  for x:=1 to 6Ø do write(btr.bta[x]);
  gotoxy(46,8);
  yesnoesccheck(37,36,'Ø36',2,8,79,23,46,8,yes,esc);
  close(backtrack)
end;

procedure checkoutcome(same:boolean;var esc:boolean);
var p:char;
    yes:boolean;
begin
  esc:=false;
  reset(ptype);
  read(ptype,p);
  close(ptype);
  window(3,11,78,19);
  if ((p='2') and same) or ((p='1') and not same) then
  begin
    askq('Ø13',3,11,78,19,52,4,yes,esc);
    if not yes and not esc then
    begin
      askq('Ø14',3,11,78,19,52,4,yes,esc);
      if not yes and not esc then
      begin
        askq('Ø15',3,11,78,19,52,4,yes,esc);
        if yes and not esc then
        begin
           clrscr;
          esc:=true;
          scrout('151',adtext)
        end
      end
      else
      begin
        clrscr;
        esc:=true;
        scrout('141',adtext);
      end
    end
```

```
    else
    begin
      clrscr;
      esc:=true;
      scrout('131',adtext)
    end
  end
  else
  begin
    askq('Ø23',3,11,78,19,52,4,yes,esc);
    if not yes and not esc then
    begin
      askq('Ø24',3,11,78,19,52,4,yes,esc);
      if not yes and not esc then
      begin
        askq('Ø25',3,11,78,19,52,4,yes,esc);
        if yes and not esc then
        begin
          clrscr;
          esc:=true;
          scrout('251',adtext)
        end
      end
      else
      begin
        clrscr;
        esc:=true;
        scrout('241',adtext);
      end
    end
    else
    begin
      clrscr;
      esc:=true;
      scrout('231',adtext)
    end
  end;
  window(2,8,79,23);
  if esc then get_return(37,36,'Ø36')
end;

procedure take_advice(var advice_taken:boolean);
begin
  advice_taken:=false;
  gotoxy(64,12);
  yesornocheck(37,36,'Ø36',2,8,79,23,64,12,advice_taken);
end;

procedure findnextcode(sameprob:boolean;var advice_token:str3);
var x,y,z:integer;
begin
  reset(currentr);
  read(currentr,cr);
  if not sameprob then
  begin
    for x:=1 to 3 do advice_token[x]:=cr.alistopp[1,x];
    for x:= 1 to 9 do
    begin
      for y:= 1 to 3 do
      cr.alistopp[x,y]:=cr.alistopp[x+1,y];
    end;
```

```
    for  x:=1 to 3 do cr.alistopp[1Ø,x]:='9'
  end
  else
  begin
    for x:=1 to 3 do advice_token[x]:=cr.alistsame[1,x];
    for x:= 1 to 9 do
    begin
      for y:= 1 to 3 do
      cr.alistsame[x,y]:=cr.alistsame[x+1,y];
    end;
    for x:=1 to 3 do cr.alistsame[1Ø,x]:='9'
  end;
  rewrite(currentr);
  write(currentr,cr);
  close(currentr)
end;


procedure displaybt;
var yes : boolean;
    ch  : char;
    s,x : integer;
begin
  assign(backtrack,'b:backtrack.dat');
  clrscr;
  scrout('Ø55',inscreens);
  messout;
  window(2,12,79,23);
  reset(backtrack);
  while not eof(backtrack) do
  begin
    if not eof(backtrack) then
    begin
      read(backtrack,btr);
      gotoxy(5,1);
      write(btr.btd[1],'/',btr.btd[2],'/',btr.btd[3]);
      s:=Ø;
      gotoxy(1,2);
      repeat
        s:=s+1;
        if not(btr.bta[s]='"') then write(btr.bta[s])
      until (s=3ØØ) or (btr.bta[s]='"')
    end;
    get_return(37,36,'Ø36');
    window(2,12,79,18);
    clrscr
  end;
  window(2,8,79,23);
  clrscr;
end;
```

```
 procedure giveadvice;
 var chins,yes,stime,advice_taken,yessame,escout :boolean;
     x,ptype:integer;
     advice_token:str3;
 begin
   escout:=false;
   chins:=false;
   assign(adtext,'b:estext.txt');
   stage1or2(stime,escout);
   if not(escout) then
   begin
     if stime then
     begin
       identifyproblem(ptype,advice_token,chins,escout);
       if not(escout) then
       begin
       if chins then
       begin
         for x:= 1 to 3 do write(advice_token[x]);
         displayadvice(advice_token,stime);
         take_advice(advice_taken);
         if advice_taken then
         begin
           clrscr;
           setupcrfile(advice_token);
           putadviceonbtrack(ptype,true,advice_token,stadvice);
         end
       end
     end
   end
   else
   begin
     establishoutcome(yessame,escout);
     if not(escout) then checkoutcome(yessame,escout);
     if not(escout) then
     begin
       findnextcode(yessame,advice_token);
       displayadvice(advice_token,stime);
       take_advice(advice_taken);
       if advice_taken then
         putadviceonbtrack(ptype,false,advice_token,ndadvice)
     end
   end
  end
end;

procedure advice;
begin
  reset(scron);
  for x:=1 to 3 do read(scron,ch);
  if ch='y' then scrandret(37,36,'Ø36',2,8,79,23,'Ø5Ø',inscreens);
  clrscr;
  giveadvice;
end;

begin
end.
```

APPENDIX IV

DIABETIC'S SYSTEM MODULES

```
(*************************************************************)
(*                                                           *)
(*  DIABETIC MANAGEMENT SYSTEM : Diabetic's System Modules   *)
(*                                                           *)
(*************************************************************)
program mainsystem(input,output);

uses crt,dos,graph3,{decl.pas} decl,scrnops4;

(*************************************************************)
(*                                                           *)
(*                      INPUT DATA MODULE                    *)
(*                                                           *)
(*************************************************************)

(*                                                           *)
(*                      Input Blood Tests                    *)
(*                                                           *)

procedure makeb;
var d4:word;
     x:integer;
begin
  rewrite(bloodf);
  for x:=1 to 6 do
  begin
    brec.bth[x]:=Ø;
    brec.btm[x]:=Ø;
    brec.br[x]:=Ø.Ø
  end;
  getdate(brec.bd[1],brec.bd[2],brec.bd[3],d4);
  write(bloodf,brec);
  close(bloodf)
end;

procedure makeu;
var d4:word;
     x:integer;
begin
  rewrite(urinef);
  for x:=1 to 4 do urec.ur[x]:=Ø.Ø;
  getdate(urec.ud[1],urec.ud[2],urec.ud[3],d4);
  write(urinef,urec);
  close(urinef)
end;

procedure checkbrec(d1,d2,d3:word;var foundrec:boolean);
begin
  foundrec:=false;
  reset(bloodf);
  rewrite(tempb);
  while not eof(bloodf) and not(foundrec) do
  begin
    read(bloodf,brec);
    if (brec.bd[1]=d1) and (brec.bd[2]=d2) and
                           (brec.bd[3]=d3) then
      foundrec:=true
    else
      write(tempb,brec)
  end;
end;
```

```
procedure iblood(var changeb:boolean);
var ampm,timeok,
    frec,delt,bloodok,tin,valok:boolean;
    l,c,bh,bm,colno,x,btcount,btl:integer;
    timeh,timem:str2;
    ch:char;
    dx1,dx2,dx3,dx4:word;
begin
  frec:=true;
  delt:=false;
  repeat
    if delt and not changeb then
    begin
      window(2,8,79,23);
      clrscr
    end;
    if delt and changeb then
    begin
      window(9,15,70,18);
      clrscr;
      scrout('102',inscreens);
      gotoxy(4,2);
    end;
    btcount:=1;
    linec:=4;
    timeok:=true;
    bloodok:=true;
    if (changeb=false) then
    begin
      window(2,8,79,23);
      scrout('001',inscreens);
      getdate(dx1,dx2,dx3,dx4);
      checkbrec(dx1,dx2,dx3,frec);
      messout;
      setwindow(9,14,70,18);
      getdate(brec.bd[1],brec.bd[2],brec.bd[3],dx4)
    end;
    l:=2;c:=4;
    if not(frec) or (delt=true) then
    begin
      for x:=1 to 6 do
      begin
        brec.bth[x]:=0;
        brec.btm[x]:=0;
        brec.br[x]:=0
      end;
      delt:=false
    end
  else
  begin
    for x:=1 to 6 do
    begin
      if x=4 then
      begin
        l:=2;
        c:=35
      end;
      gotoxy(c,l);
```

```
    if brec.bth[x]<>Ø then
    begin
      writetime(c,l,brec.bth[x],brec.btm[x]);
      gotoxy(c+21,l);
      if (brec.br[x]=4.5) or (brec.br[x]=6.5) then
        write(brec.br[x]:2:1)
      else
        if brec.br[x]>1Ø then write(brec.br[x]:2:Ø,' ')
        else
          write(brec.br[x]:1:Ø,'  ');
      l:=l+1
    end
  end;
end;
l:=2; c:=4;
repeat
  if l=5 then
  begin
    l:=2;c:=35;
  end;
  gotoxy(c,l);
  readtime(4,4,'ØØ4',9,14,7Ø,18,c,l,timeh,timem,ampm,bh,bm);
  if not(retck) then
  begin
    brec.btm[btcount]:=bm;
    brec.bth[btcount]:=bh;
    repeat
      tin:=false;
      valok:=true;
      gotoxy(c+21,l);
      getkey(4,4,'ØØ4',9,14,7Ø,18,c+21,l,ch);
      if ch=£Ø then ch:=readkey;
      if (ord(ch)<>83) and  (ord(ch)<>27) and
                            (ord(ch)<>13) then
      begin
        write(ch);
        case ord(ch) of
        49 : begin
               getkey(4,4,'ØØ4',9,14,7Ø,18,c+23,l,ch);
               if ord(ch)<>27 then write(ch);
               case ord(ch) of
                 55 : begin
                        brec.br[btcount]:=17;
                        getkey(4,4,'ØØ4',9,14,7Ø,18,
                                                c+24,l,ch);
                        if ((ord(ch)<>13) and not
                          ((ord(ch)=27) or (ord(ch)=83))) then
                            valok:=false
                      end;
                 49 : begin
                        brec.br[btcount]:=11;
                        getkey(4,4,'ØØ4',9,14,7Ø,18,
                                                c+24,l,ch);
                        if ((ord(ch)<>13) and not
                          ((ord(ch)=27) or (ord(ch)=83))) then
                          valok:=false
                      end;
              13,27 : brec.br[btcount]:=1
               else
                  valok:=false
               end
```

```
      end
  57 : begin
         getkey(4,4,'004',9,14,70,18,c+23,1,ch);
         if ord(ch)<>27 then write(ch);
         if (ord(ch)<>13) and not
           ((ord(ch)=27) or (ord(ch)=83)) then
           valok:=false
         else
           brec.br[btcount]:=9
       end;
  52 : begin
         getkey(4,4,'004',9,14,70,18,c+23,1,ch);
         write(ch);
         case ord(ch) of
         46 : begin
                getkey(4,4,'004',9,14,70,18,c+24,1,ch);
                write(ch);
                if ord(ch)<>53 then
                  valok:=false
                else
                begin
                  getkey(4,4,'004',9,14,70,18,
                                           c+25,1,ch);
                  if (ord(ch)<>13) and not
                    ((ord(ch)=27) or (ord(ch)=83)) then
                    valok:=false
                  else
                    brec.br[btcount]:=4.5
                end
              end;
         52 : begin
                getkey(4,4,'004',9,14,70,18,c+24,1,ch);
                if (ord(ch)<>13) and not
                  ((ord(ch)=27) or (ord(ch)=83)) then
                  valok:=false
                else
                brec.br[btcount]:=44
              end
         else
         valok:=false
       end
     end;
54 : begin
       getkey(4,4,'004',9,14,70,18,c+23,1,ch);
       if ord(ch)<>27 then write(ch);
       if ord(ch)<>46 then
         valok:=false
       else
       begin
         getkey(4,4,'004',9,14,70,18,c+24,1,ch);
         write(ch);
         if ord(ch)<>53 then valok:=false
         else
         begin
           getkey(4,4,'004',9,14,70,18,c+25,1,ch);
           if (ord(ch)<>13) and not
             ((ord(ch)=27) or (ord(ch)=83)) then
             valok:=false
           else
             brec.br[btcount]:=6.5
         end
```

```
              end
            end;
       5Ø : begin
              getkey(4,4,'ØØ4',9,14,7Ø,18,c+24,1,ch);
              if ord(ch)<>27 then write(ch);
              case ord(ch) of
                13,27 : brec.br[btcount]:=2;
                   56 : begin
                          getkey(4,4,'ØØ4',9,14,7Ø,18,
                                                    c+25,1,ch);
                          write(ch);
                          if ord(ch)<>13 then
                            valok:=false
                          else
                            brec.br[btcount]:=28
                        end
                        else
                          valok:=false
              end
            end
            else
              valok:=false
           end
         end;
         if valok=false then errmess(23,13,4,9,14,7Ø,18,
                                          wherex,wherey)
      until (ord(ch)=27) or valok or (ord(ch)=83)
     end;
     l:=l+1;
     btcount:=btcount+1
   until (ord(ch)=27) or (btcount=7) or (ord(ch)=83);
   if ord(ch)=83 then delt:=true
 until delt=false;
 if not(frec) then
 begin
   if btcount<7 then
   begin
     for x:=btcount to 6 do
     begin
       brec.bth[x]:=Ø;
       brec.btm[x]:=Ø;
       brec.br[x]:=Ø
     end
   end
 end;
 get_return(4,4,'ØØ4');
 write(tempb,brec);
 reset(tempb);
 rewrite(bloodf);
 while not eof(tempb) do
 begin
   read(tempb,brec);
   write(bloodf,brec)
 end;
 rec_mon_blood(brec);
 changeb:=false;
 close(tempb);
 close(bloodf)
end;
```

```
(*                                                               *)
(*                     Input Urine Tests                         *)
(*                                                               *)

procedure checkurec(d1,d2,d3:word;var foundrec:boolean);
begin
  foundrec:=false;
  rewrite(tempu);
  reset(urinef);
  while not(eof(urinef)) and not(foundrec) do
  begin
    read(urinef,urec);
    if (urec.ud[1]=d1)and(urec.ud[2]=d2)and(urec.ud[3]=d3) then
      foundrec:=true
    else
      write(tempu,urec);
  end;
end;

procedure iurine(var changeu:boolean);
var   testok : boolean;
      u,ucount:integer;
         utest:real;
      frec,delt,regtest,utok:boolean;
      ch:char;
      du1,du2,du3,du4:word;
begin
  frec:=true;
  delt:=false;
  repeat
    if changeu=false then
    begin
      window(2,8,79,23);
      scrout('ØØ2',inscreens);
      messout;
      setwindow(9,14,7Ø,18);
      if delt=false then
      begin
        getdate(du1,du2,du3,du4);
        checkurec(du1,du2,du3,frec);
      end
      else
        delt:=false;
      getdate(urec.ud[1],urec.ud[2],urec.ud[3],du4);
    end;
    linec:=Ø;
    ucount:=Ø;
    if not(frec) then
      for x:=1 to 4 do urec.ur[x]:=Ø
      else
      begin
        window(9,14,7Ø,18);
      c:=24;
      linec:=Ø;
      for x:=1 to 4 do
      begin
        linec:=linec+2;
        if x>2 then c:=5Ø;
        if x=3 then linec:=2;
        gotoxy(c,linec);
```

```
    if urec.ur[x]=9 then write('neg')
    else
      if urec.ur[x]<1 then write(urec.ur[x]:3:2)
      else
        if urec.ur[x]>Ø.5 then write(urec.ur[x]:1:Ø,'  ')
  end;
  frec:=false
end;
linec:=Ø;
ucount:=Ø;
repeat
  ucount:=ucount+1;
  regtest:=false;
  utok:=true;
  if ucount=3 then linec:=Ø;
  linec:=linec+2;
  x:=Ø;
  repeat
    utok:=true;
    if ucount>2 then
      gotoxy(5Ø,linec)
    else
      gotoxy(24,linec);
    x:=x+1;
    getkey(5,5,'ØØ5',9,14,7Ø,18,wherex,wherey,ch);
    blankmess(26,13,9,14,7Ø,18,wherex,wherey);
    if ch=£Ø then ch:=readkey;
    if (ord(ch)<>83) and (ord(ch)<>27) then write(ch);
    case ord(ch) of
    78,11Ø : begin
               getkey(5,5,'ØØ5',9,14,7Ø,18,wherex,
                                           wherey,ch);
               if (ord(ch)<>13) and (ord(ch)<>27) then
               begin
                 if ord(ch)=83 then
                   delt:=true
                 else
                   utok:=false
               end
               else
                 urec.ur[ucount]:=9;
             end;
        48 : begin
               getkey(5,5,'ØØ5',9,14,7Ø,18,wherex,
                                           wherey,ch);
               if (ord(ch)<>83) and (ord(ch)<>27) then
                 write(ch);
               if ord(ch)=46 then
               begin
                 getkey(5,5,'ØØ5',9,14,7Ø,18,wherex,
                                             wherey,ch);
                 if (ord(ch)<>83) and (ord(ch)<>27) then
                   write(ch);
                 case ord(ch) of
                 49 : begin
                        getkey(5,5,'ØØ5',9,14,7Ø,18,
                                       wherex,wherey,ch);
                        if (ord(ch)<>13) and (ord(ch)<>27)
                          then
```

```
                    begin
                      if ord(ch)=83 then
                        delt:=true
                      else
                        utok:=false
                    end
                    else
                      urec.ur[ucount]:=Ø.1
                  end;
              53 : begin
                    getkey(5,5,'ØØ5',9,14,7Ø,18,
                                     wherex,wherey,ch);
                    if (ord(ch)<>13) and (ord(ch)<>27)
                      then
                    begin
                      if ord(ch)=83 then
                        delt:=true
                      else
                        utok:=false
                    end
                    else
                      urec.ur[ucount]:=Ø.5
                  end;
              5Ø : begin
                    getkey(5,5,'ØØ5',9,14,7Ø,18,
                                     wherex,wherey,ch);
                    if (ord(ch)<>83) and (ord(ch)<>27)
                      then
                      write(ch);
                    if ord(ch)=53 then
                    begin
                      getkey(5,5,'ØØ5',9,14,7Ø,18,
                                     wherex,wherey,ch);
                      if (ord(ch)<>13) and
                                     (ord(ch)<>27) then
                      begin
                        if ord(ch)=83 then
                          delt:=true
                        else
                          utok:=false
                      end
                      else
                        urec.ur[ucount]:=Ø.25
                    end
                    else
                      utok:=false
                  end
                  else
                    utok:=false
                end
              end
            end;
49,5Ø,51,52,53 : begin
                  urec.ur[ucount]:=ord(ch)-48;
                  getkey(5,5,'ØØ5',9,14,7Ø,18,wherex,
                                     wherey,ch);
```

```
                    if (ord(ch)<>13) and (ord(ch)<>27) then
                    begin
                      if (ord(ch)=83) then
                        delt:=true
                      else
                        utok:=false
                    end
                  end
                  else
                    if (ord(ch)=83) then
                  delt:=true
             else
               utok:=false
           end;
           if (ord(ch)=83) then delt:=true;
           if not(utok) then errmess(23,13,4,9,14,70,18,
                                              wherex,wherey);
       until utok or (ord(ch)=27) or (ord(ch)=83) or
                     (ord(ch)=13) or (ord(ch)=4);
     until (ucount=4) or (ord(ch)=83);
   until delt=false;
   window(2,8,79,23);
   get_return(5,5,'005');
   write(tempu,urec);
   rec_mon_urine(urec);
   reset(tempu);
   rewrite(urinef);
   while not eof(tempu) do
   begin
     read(tempu,urec);
     write(urinef,urec)
   end;
   close(tempu);
   close(urinef)
 end;                    (* end urine tests *)

 (*                                                        *)
 (*                    Input Carbohydrate                  *)
 (*                                                        *)

 procedure idiet;
 var frec,delt,chook,chok: boolean;
     num1,num2,dc,icho,dietc: integer;
     cho:string;
     choch:char;
     d:word;
     dt:tim;
 begin
   frec:=false;
   clrscr;
   scrout('003',inscreens);
   messout;
   setwindow(9,14,70,18);
   rewrite(tempd);
   reset(dietf);
```

```
while not eof(dietf) and not(frec) do
begin
  read(dietf,drec);
  getdate(td[1],td[2],td[3],d);
  finddate(drec.dd,td,frec);
  if not frec then write(tempd,drec)
end;
repeat
  if delt=true then clrscr;
  delt:=false;
  scrout('103',inscreens);
  if not frec then for x:=1 to 6 do drec.cho[x]:=0
  else
  begin
    dc:=23;linec:=2;
    if frec then
      for x:=1 to 6 do
      begin
        if x=4 then
        begin
          dc:=51;linec:=2;
        end;
        gotoxy(dc,linec);
        write(drec.cho[x]);
        linec:=linec+1
      end
    end;
    linec:=1;
    dietc:=0;
    repeat
      dietc:=dietc+1;
      if dietc=4 then linec:=1;
      linec:=linec+1;
      repeat
        if dietc>3 then
          dc:=51
        else
          dc:=23;
        gotoxy(dc,linec);
        chok:=true;
        getkey(9,9,'009',9,14,70,18,dc,linec,choch);
        blankmess(25,13,9,14,70,18,dc,linec);
        if choch=£0 then choch:=readkey;
        if ord(choch)=83 then
          delt:=true
        else
          if (ord(choch)<>13) or (ord(choch)<>83)
                                  or (ord(choch)<>59) then
        begin
          num1:=ord(choch);
          if (num1>47) and (num1<57) then
          begin
            getkey(9,9,'009',9,14,70,18,dc,linec,choch);
            blankmess(25,13,9,14,70,18,dc,linec);
            if ord(choch)<>13 then
            begin
              num2:=ord(choch);
```

```
                if (num2>47) and (num2<57) then
                begin
                  num1:=((num1-48)*10)+(num2-48);
                  write(num1);
                  repeat
                    getkey(14,6,'009',9,14,70,18,
                                         wherex,wherey,choch)
                  until ord(choch)=13
                end
                else
                begin
                  chok:=false;
                  errmess(25,13,2,9,14,70,18,dc,linec)
                end
              end
              else
              begin
                num1:=(num1-48);
                write(num1)
              end;
            end
            else
            begin
              chok:=false;
              errmess(25,13,2,9,14,70,18,dc,linec);
            end;
            drec.cho[dietc]:=num1
          end;
        until (ord(choch)=13) or (ord(choch)=83)
      until (dietc=6) or (ord(choch)=83)
    until (delt=false);
    window(2,8,79,23);
    get_return(14,6,'009');
    getdate(drec.dd[1],drec.dd[2],drec.dd[3],d);
    write(tempd,drec);
    reset(tempd);
    rewrite(dietf);
    while not eof(tempd) do
    begin
      read(tempd,drec);
      write(dietf,drec)
    end;
    close(tempd);
    close(dietf)
  end;                  (* end diet *)


(*                                                              *)
(*                         Input Insulin                        *)
(*                                                              *)

procedure iinsulin;
var c,y,a,b,x,insc:integer;
    frec,errins:boolean;
    d:word;
    td:tim;
    i:array[1..4] of integer;
begin
  assign(insuf,'b:insuf.dat');
  assign(tempi,'b:tempi.dat');
  frec:=false;
```

```
clrscr;
scrout('004',inscreens);
insul.noinj:=2;
if insul.noinJ=2 then scrout('005',inscreens)
else
  scrout('006',INSCREENS);
messout;
window(2,8,79,23);
rewrite(tempi);
reset(insuf);
while not eof(insuf) and not(frec) do
begin
  read(insuf,inrec);
  getdate(td[1],td[2],td[3],d);
  finddate(inrec.ind,td,frec);
  if not frec then write(tempi,inrec)
end;
if not frec then
  for x:= 1 to 2 do
    for y:=1 to 2 do
      inrec.inr[x,y]:=0;
getdate(inrec.ind[1],inrec.ind[2],inrec.ind[3],d);
if frec then
begin
  i[1]:=inrec.inr[1,1];
  i[2]:=inrec.inr[1,2];
  i[3]:=inrec.inr[2,1];
  i[4]:=inrec.inr[2,2]
end;
c:=0;
for x:=1 to 2 do
begin
  if x=1 then setwindow(9,16,70,18)
  else
  begin
    window(8,14,71,20);
    clrscr;
    if insul.noinj=1 then
      scrout('106',inscreens)
    else
      scrout('105',inscreens);
    setwindow(9,16,70,18)
  end;
  if frec then
  begin
    for a:=1 to 2 do
      for b:=1 to 2 do
        write('    ',inrec.inr[a,b]);
  end;
  b:=0;
  gotoxy(47,1);
  write(i[x+c]);
  gotoxy(47,3);
  c:=c+1;
  write(i[x+c]);
  for a:=1 to insul.noinj do
  begin
    if insul.noinj=1 then
      b:=2
    else
      b:=b+a;
```

```
      gotoxy(47,b);
      getkey(10,3,'007',2,8,79,23,wherex,wherey,ch);
      write(ch);
      if (ch in ['0'..'9']) then
        inrec.inr[x,a]:=((ord(ch)-48)*10)
      else
      begin
        write('errmess');
        errins:=true
      end;
      getkey(10,3,'007',2,8,79,23,wherex,wherey,ch);
      write(ch);
      if ch in ['0'..'9'] then
        inrec.inr[x,a]:=inrec.inr[x,a]+(ord(ch)-48)
      else
      begin
        write('errmess');
        errins:=true
      end
    end;
    get_return(14,6,'007')
  end;
  getdate(inrec.ind[1],inrec.ind[2],inrec.ind[3],d);
  for a:=1 to 2 do
    for b:=1 to 2 do
      write('    ',inrec.inr[a,b]);
  write(tempi,inrec);
  reset(tempi);
  rewrite(insuf);
  while not eof(tempi) do
  begin
    read(tempi,inrec);
    write(insuf,inrec)
  end;
  close(insuf);
  close(tempi)
end;                    (*end linsulin*)


(*                                                              *)
(*                       Input Exercise                         *)
(*                                                              *)

procedure iexercise;
var timeh, timem : array[1..2] of str2;
    typeex   : char;
    timeno   : integer;
    frec, typeok, ampm, delt, timeok : boolean;
    td       : tim;
    d        : word;
begin
  assign(tempe,'b:tempe.dat');
  clrscr;
  frec:=false;
  scrout('007',inscreens);
  messout;
  setwindow(9,16,70,18);
  rewrite(tempe);
  reset(exerf);
```

```
while not eof(exerf) and not(frec) do
begin
  read(exerf,exrec);
  getdate(td[1],td[2],td[3],d);
  finddate(exrec.ed,td,frec);
  if not frec then write(tempe,exrec)
end;
repeat
  delt:=false;
  typeok:=false;
  repeat
    if frec then
    begin
      gotoxy(34,1);
      write(exrec.etype);
      for x:=1 to 2 do
      begin
        gotoxy(34,x+1);
        writetime(34,x+1,exrec.etime[1,x],exrec.etime[2,x]);
        frec:=false
      end
    end
    else
    begin
      exrec.etype:=Ø;
      exrec.etime[1,1]:=Ø;exrec.etime[2,1]:=Ø;
      exrec.etime[1,2]:=Ø;exrec.etime[2,2]:=Ø
    end;
    gotoxy(34,1);
    getkey(14,6,'Ø11',9,16,7Ø,18,34,1,typeex);
    if typeex=£Ø then typeex:=readkey;
    if ord(typeex)=83 then delt:=true
    else
      if (ord(typeex)=49) or (ord(typeex)=5Ø) or
                             (ord(typeex)=51) then
      begin
        typeok:=true;
        write(chr(ord(typeex)));
        exrec.etype:=ord(typeex)-48
      end
      else
      begin
      end
    until (typeok=true) or (ord(typeex)=83);
    linec:=1;
    for timeno:=1 to 2 do
    begin
      linec:=linec+1;
      gotoxy(34,linec);
      readtime(14,6,'Ø11',9,16,7Ø,18,34,linec,timeh[timeno],
               timem[timeno],ampm,exrec.etime[1,timeno],
               exrec.etime[2,timeno])
    end;
   until delt=false;
   get_return(14,6,'Ø11');
   getdate(exrec.ed[1],exrec.ed[2],exrec.ed[3],d);
   write(tempe,exrec);
   reset(tempe);
   rewrite(exerf);
```

```
    while not eof(tempe) do
    begin
      read(tempe,exrec);
      write(exerf,exrec)
    end;
    close(exerf);
    close(tempe)
end;

(*                                                              *)
(*                         Input Hypos                          *)
(*                                                              *)

procedure Ihypos;
var timehm :array[1..2] of str2;
    frec,delt,timok,nomorehypos,ampm :boolean;
    xc,yc,c,hypoc,x,hypohrs,hypomins:integer;
    ch:char;
    d:word;
    td:tim;
begin
  assign(temphy,'b:tempf.dat');
  delt:=false;
  repeat
    clrscr;
    scrout('ØØ8',inscreens);
    messout;
    setwindow(9,15,7Ø,18);
    rewrite(temphy);
    reset(hypof);
    frec:=false;
    while not eof(hypof) and not(frec) and not(delt) do
    begin
      read(hypof,hyrec);
      getdate(td[1],td[2],td[3],d);
      finddate(hyrec.hyd,td,frec);
      if not frec then write(temphy,hyrec)
    end;
    if frec then
    begin
      frec:=false;
      linec:=1;
      c:=14;
      for x:=1 to 6 do
      begin
        if hyrec.ht[1,x]<>Ø then
        begin
          gotoxy(c,linec);
          writetime(c,linec,hyrec.ht[1,x],hyrec.ht[2,x]);
          linec:=linec+1;
          if x=3 then
          begin
            linec:=1;
            c:=38
          end
        end
      end
    end
    else
```

```
    begin
      if not(frec) or delt then
        for x:=1 to 6 do
        begin
          hyrec.ht[1,x]:=Ø;hyrec.ht[2,x]:=Ø;
        end
    end;
    linec:=1;
    c:=14;
    hypoc:=1;
    repeat
      if hypoc=4 then linec:=1;c:=38;
      linec:=linec+1;
      if hypoc=1 then
        gotoxy(c,linec-1)
      else
        gotoxy(c,linec);
      readtime(14,6,'ØØ8',9,14,7Ø,18,c,linec,
                             timehm[1],timehm[2],ampm,
                             hyrec.ht[1,hypoc],hyrec.ht[2,hypoc]);
      hypoc:=hypoc+1;
      repeat
        xc:=wherex; yc:=wherey;
        getkey(14,6,'ØØ8',9,14,7Ø,18,xc,yc,ch);
        if ch=£Ø then ch:=readkey;
        if ord(ch)=83 then delt:=true
      until (ord(ch)=13) or (ord(ch)=27) or (ord(ch)=83);
    until (hypoc=7) or (ord(ch)=27) or (ord(ch)=83) or
          (ord(ch)=59)
  until delt=false;
  get_return(14,6,'ØØ8');
  getdate(hyrec.hyd[1],hyrec.hyd[2],hyrec.hyd[3],d);
  write(temphy,hyrec);
  reset(temphy);
  rewrite(hypof);
  while not eof(temphy) do
  begin
    read(temphy,hyrec);
    write(hypof,hyrec)
  end;
  rec_mon_hypo(hyrec);
  close(temphy);
  close(hypof)
end;

(*                                                              *)
(*                      Input Health                            *)
(*                                                              *)

procedure ihealth;
const maxsyms=7;
var ox,oy,symptoms:integer;
    yn:char;
    frec,delt,yornok:boolean;
    yorn:array[1..maxsyms] of char;
    d:word;
    td:tim;
begin
  delt:=false;
  assign(temphe,'b:temphe.dat');
  rewrite(temphe);
```

```
reset(healf);
frec:=false;
while not eof(healf) and not(frec) do
begin
  read(healf,herec);
  getdate(td[1],td[2],td[3],d);
  finddate(herec.hed,td,frec);
  if not frec then write(temphe,herec)
end;
repeat
  if delt then  for x:=1 to 7 do herec.htype[x]:='n';
  delt:=false;
  rewrite(healf);
  window(2,8,79,23);
  clrscr;
  scrout('ØØ9',inscreens);
  messout;
  setwindow(9,15,7Ø,18);
  if frec then
  begin
    for x:=1 to 4 do
    begin
      gotoxy(48,x);
      write(herec.htype[x]);
    end;
    frec:=false
  end;
  linec:=Ø;
  symptoms:=Ø;
  repeat
    symptoms:=symptoms + 1 ;
    yornok:=false;
    linec:=linec+1;
    repeat
      gotoxy(48,linec);
      ox:=wherex;
      oy:=wherey;
      getkey(6,14,'ØØ9',9,15,7Ø,18,ox,oy,yn);
      blankmess(26,13,9,15,7Ø,18,ox,oy);
      if yn=£Ø then yn:=readkey;
      case ord(yn) of
      121 : begin
              yorn[symptoms]:='y';
              yornok:=true
            end;
      11Ø : begin
              yorn[symptoms]:='n';
              yornok:=true
            end;
      83  : begin
              delt:=true
            end;
      72  : begin
              if symptoms=5 then linec:=3
              else
                linec:=linec-2;
              symptoms:=symptoms-2
            end
```

```
        else
          errmess(26,13,2,9,15,70,18,ox-1,oy-1)
        end;
      until (yornok=true) or (ord(yn)=83) or (ord(yn)=72);
      if yornok then herec.htype[symptoms]:=yorn[symptoms];
      if (delt=false) and not(ord(yn)=72) then
        write(yorn[symptoms])
    until (symptoms=4) or (delt=true);
    repeat
      gotoxy(78,15);
      getkey(14,6,'Ø1Ø',2,8,79,23,ox-1,oy-1,yn);
      if ord(yn)=83 then delt:=true;
    unti l (ord(yn)=13) or delt;
  until delt=false;
  window(2,8,79,23);
  get_return(14,6,'Ø1Ø');
  getdate(herec.hed[1],herec.hed[2],herec.hed[3],d);
  write(temphe,herec);
  reset(temphe);
  rewrite(healf);
  while not eof(temphe) do
  begin
    read(temphe,herec);
    write(healf,herec)
  end;
  close(temphe);
  close(healf)
end;


(*                                                              *)
(*                          Input Stress                        *)
(*                                                              *)

procedure iemotion;
const maxems=4;
var ox,oy,emotions:integer;
    frec,delt,yornok:boolean;
    yorn:array[1..maxems] of char;
    yn:char;
    d:word;
    td:tim;
begin
  assign(tempem,'b:tempem.dat');
  rewrite(tempem);
  reset(emotf);
  frec:=false;
  delt:=false;
  while not eof(emotf) and not(frec) do
  begin
    read(emotf,emrec);
    getdate(td[1],td[2],td[3],d);
    finddate(emrec.emd,td,frec);
    if not frec then write(tempem,emrec)
  end;
  repeat
    if delt then for x:=1 to 3 do emrec.emtype[x]:=' ';
    delt :=false;
    window(2,8,79,23);
    clrscr;
    scrout('Ø1Ø',inscreens);
```

```
messout;
setwindow(2,8,79,23);
setwindow(9,14,70,18);
if frec then
begin
  for x:=1 to 3 do
  begin
    gotoxy(42,x+1);
    write(emrec.emtype[x])
  end;
end;
linec:=2;
emotions:=1;
repeat
  yornok:=false;
  gotoxy(42,linec);
  repeat
  until keypressed;
  yn:=readkey;
  ox:=wherex;
  oy:=wherey;
  blankmess(26,13,9,14,70,18,ox,oy);
  gotoxy(ox,oy);
  if yn=£0 then
  begin
    yn:=readkey;
    if ord(yn)=59 then
      hhelp
    else
    if ord(yn)=72 then
    begin
      if emotions>1 then
      begin
        emotions:=emotions-1;
        if linec>2 then linec:=linec-1;
          gotoxy(42,linec)
      end
    end
    else
      if ord(yn)=80 then
      begin
        if emotions<3 then
        begin
          emotions:=emotions+1;
          if linec<4 then linec:=linec+1;
          gotoxy(42,linec)
        end
     end
     else
       if ord(yn)=83 then delt:=true
   end
   else
     case ord(yn) of
     121 : begin
             emrec.emtype[emotions]:='y';
             gotoxy(42,linec);
             write('y');
             emotions:=emotions+1;
             linec:=linec+1;
             yornok:=true
           end;
```

```
        110 : begin
                emrec.emtype[emotions]:='n';
                gotoxy(42,linec);
                write('n');
                emotions:=emotions+1;
                linec:=linec+1;
                yornok:=true
              end;
        83  : begin
                delt:=true
              end;
        else
          errmess(26,13,2,9,14,70,18,ox,oy)
      end;
    until (emotions=4) or (delt=true);
    repeat
      getkey(14,6,'009',2,8,79,23,wherex,wherey,yn);
      if ord(yn)=83 then delt:=true;
      if ord(yn)=59 then(*help*)
    until (ord(yn)=13) or delt;
  until delt=false;
  get_return(14,6,'013');
  getdate(emrec.emd[1],emrec.emd[2],emrec.emd[3],d);
  write(tempem,emrec);
  reset(tempem);
  rewrite(emotf);
  while not eof(tempem) do
  begin
    read(tempem,emrec);
    write(emotf,emrec)
  end;
  close(tempem);
  close(emotf)
end;                      (* end health *)


(*                                                              *)
(*                       Input Holidays                         *)
(*                                                              *)

procedure iholidays;
var holcount : integer;
    time:array[1..2] of string[5];
    delt,timok,yest:boolean;
    d:word;
begin
  assign(tempho,'b:tempho.dat');
  repeat
    delt:=false;
    clrscr;
    scrout('011',inscreens);
    messout;
    setwindow(9,16,70,18);
    linec:=2;
    repeat
      gotoxy(36,linec);
      yesornocheck(14,6,'012',9,16,70,18,36,linec,yest);
      if yest then horec.hols:=1;
      getkey(14,6,'012',9,16,70,18,wherex,wherey,ch);
      if ch=£0 then ch:=readkey;
```

```
      if ord(ch)=83 then delt:=true
    until (ord(ch)=13) or (ord(ch)=83)
  until delt=false;
  get_return(14,6,'Ø12');
  rewrite(tempho);
  reset(holsf);
  while not eof(holsf) do
  begin
    read(holsf,horec);
    write(tempho,horec)
  end;
  getdate(horec.hod[1],horec.hod[2],horec.hod[3],d);
  write(tempho,horec);
  reset(tempho);
  rewrite(holsf);
  while not eof(tempho) do
  begin
    read(tempho,horec);
    write(holsf,horec)
  end;
  close(tempho);
  close(holsf)
end;


(*                                                              *)
(*                   Input Extra Notes                          *)
(*                                                              *)

procedure Iextranotes;
var chstr : string;
    scrcount,chcount,x,y,b,linesize,chnum : integer;
    ch,chin : char;
    frec,delt : boolean;
    d : word;
    td : tim;
begin
  assign(tempn,'b:tempn.dat');
  assign(notesf,'b:notesf.dat');
  rewrite(tempn);
  reset(notesf);
  frec:=false;
  while not eof(notesf) and not(frec) do
  begin
    if not eof(notesf) then read(notesf,norec);
    getdate(td[1],td[2],td[3],d);
    finddate(norec.nod,td,frec);
    if not frec then write(tempn,norec)
  end;
  repeat
    delt:=false;
    setwindow(2,8,79,23);
    clrscr;
    scrout('Ø12',inscreens);
    messout;
    setwindow(2,8,79,23);
    setwindow(5,15,75,18);
    if frec then
    begin
      for x:=1 to 4 do
      begin
```

```
      for y:=1 to 70 do
      begin
        gotoxy(y,x);
        write(norec.extras[x,y]);
      end;
    end;
  end;
  if not frec then
    for a:=1 to 4 do
      for b:=1 to 70 do norec.extras[a,b]:=' ';
  gotoxy(1,1);
  linesize:=1;
  chnum:=1;
  repeat
    repeat
    until keypressed;
    chin:=readkey;
    if chin=£0 then
    begin
      chin:=readkey;
      if ord(chin)=59 then hhelp
      else
        if (ord(chin)=80) and (linesize<4) then
          linesize:=linesize+1
        else
          if (ord(chin)=72) and (linesize>1) then
            linesize:=linesize-1
          else
            if (ord(chin)=77) and (chnum<69) then
              chnum:=chnum+1
            else
              if (ord(chin)=75) and (chnum>1) then
                chnum:=chnum-1;
      gotoxy(chnum,linesize)
    end
    else
      if ord(chin)=83 then delt:=true
      else
        if (delt=false)and((ord(chin)<>27)and((ord(chin)>31)
                          and (ord(chin)<128))) then
        begin
          ch:=chr(ord(chin));
          gotoxy(chnum,linesize);
          write(ch);
          norec.extras[linesize,chnum]:=ch;
          chnum:=chnum+1;
          if chnum=70 then
          begin
            chnum:=1;
            linesize:=linesize+1;
            if linesize>4 then (*eeror*)
          end;
        end
      until (linesize=5) or (ord(chin)=27) or (delt = true);
    until delt=false;
    window(2,8,79,23);
    get_return(14,6,'014');
    getdate(norec.nod[1],norec.nod[2],norec.nod[3],d);
    write(tempn,norec);
    reset(tempn);
    rewrite(notesf);
```

```
  while not eof(tempn) do
  begin
    read(tempn,norec);
    write(notesf,norec)
  end;
  close(notesf);close(tempn)
end;                           (* extranotes *)
```

APPENDIX V

CLINICIAN'S SYSTEM MODULES

```
(*****************************************************************)
(*                                                               *)
(* DIABETIC MANAGEMENT SYSTEM   : Clinician's Utilities         *)
(*                                                               *)
(*****************************************************************)

program mainsystem(input,output);

uses crt,printer,dos,graph3,{decl.pas} decl,scrnops4;

type randomrec=record
       ltext:string
     end;

     randomfile=file of randomrec;

     insr = record
       brand      : packed array [1..30] of char;
       onset      : integer;
       endaction  : integer
     end;

     insf = file of insr;

var  insfile,
     tempins   : insf;
     insrec    : insr;
     z         : integer;
     erfile    : randomfile;
     errec     : randomrec;
     retck     : boolean;
     tempst2   : ndstagefile;
     inst      ,
     temp      ,
     clintext  : text;

 (*****************************************************************)
 (*                                                               *)
 (*                    CHANGE RULES MODULE                        *)
 (*                                                               *)
 (*****************************************************************)

                                  (* check with user for amendment*)
                                  (* or deletion                  *)
 procedure ammendordel(ac:str3;aord:boolean;var filen:text);
 var p,same,x:integer;
 begin
   window(3,11,78,15);
   clrscr;
   reset(filen);
   rewrite(temp);
   while not eof(filen) and (same<>3) do
   begin
     repeat
       read(filen,ch);
       write(temp,ch);
     until (ch='"') or eof(filen);
     same:=0;
```

```
    for x:=1 to 3 do
    begin
      read(filen,ch);
      write(temp,ch);
      if ch=ac[x] then same:=same+1
    end;
  end;
  read(filen,ch);
  write(temp,ch);
  if same=3 then
  begin
    if aord then
    begin
      while ord(ch)<>27 do
      begin
        getkey('ØØ3',3,11,78,15,wherex,wherey,ch);
        if ord(ch)<>27 then
        begin
          write(temp,ch);
          write(ch)
        end;
        if p>7Ø then writeln(temp);
      end
    end
    else
    begin
      repeat
        if not eof(filen) then read(filen,ch);
      until ch='"'
    end;
    write(temp,ch);
    while not eof(filen) do
    begin
      read(filen,ch);
      write(temp,ch)
    end;
    window(2,8,79,23);
    blankmess(4Ø,13,2,8,79,23,5Ø,13);
  end;
end;
                              (* validate the text code entered*)
                              (* by the user                   *)
procedure checkcode(ac:str3;var filen:text;var ft:boolean);
var x,same:integer;
    foundtext:boolean;
begin
  reset(filen);
  ft:=false;
  same:=Ø;
  while not(eof(filen)) and not(ft) do
  begin
    same:=Ø;
    repeat
      read(filen,ch);
    until (ch='"') or eof(filen);
```

```
    if (ch='"') and not(ft) then
    begin
      for x:=1 to 3 do
      begin
        if not eof(filen) then read(filen,ch);
        if ch=ac[x] then same:=same+1
      end;
      if not eof(filen) then read(filen,ch);
      if same=3 then ft:=true;
    end
    else
      if not eof(filen) then read(filen,ch)
  end;
end;

                                (*      find and display text     *)
procedure puttexton(rt:boolean;ac:str3;var filen:text);
var ftext:boolean;
begin
  gotoxy(20,2);
  for x:=1 to 3 do write(ac[x]);
  if rt then window(2,11,79,15)
  else
    window(2,10,79,14);
  checkcode(ac,filen,ftext);
  if not ftext then
    writemess('310')
  else
    scrout(ac,filen);
  if rt then
    setwindow(3,11,78,15)
  else
    setwindow(3,17,78,18);
end;

                                (* read text code from keyboard  *)
procedure readcode(rt:boolean;ch1:char;var ac:str3;
                                         var filen:text);
var err,ftext:boolean;
begin
  repeat
    err:=false;
    if (ord(ch1)>47) and (ord(ch1)<57) then
    begin
      ac[1]:=ch1;
      getkey('001',2,8,79,23,wherex,wherey,ch1);
      if (ord(ch1)>47) and (ord(ch1)<57) then
      begin
        ac[2]:=ch1;
        getkey('001',2,8,79,23,wherex,wherey,ch1);
        if (ord(ch1)>47) and (ord(ch1)<57) then
        begin
          ac[3]:=ch1;
          puttexton(rt,ac,filen)
        end
        else
        begin
          err:=true;
          errmess('431')
        end
      end
```

```
      else
      begin
        err:=true;
        errmess('432')
      end
    end
    else
    begin
      err:true;
      errmess('433')
    end;
    if err then getkey('ØØ1',2,8,79,23,wherex,wherey,ch1)
  until err=false
end;

                                (*          display rules          *)
procedure writerules(cr:boolean;ac:str3);
var same,x,y:integer;
    foundtext:boolean;
begin
  reset(stage2);
  assign(tempst2,'b:tempst2.dat');
  foundtext:=false;
  rewrite(tempst2);
  same:=Ø;
  if not eof(stage2) then  read(stage2,nd);
  for x:=1 to 3 do
  begin
    if ac[x]=nd.acode[x] then same:=same+1
  end;
  if same=3 then
  begin
    foundtext:=true;
    if cr=true then
      gotoxy(21,1Ø)
    else
      gotoxy(21,11);
    for x:=1 to 1Ø do
    begin
      for y:=1 to 3 do write(nd.samelist[x,y]);
      if x<>1Ø then write(', ')
    end;
    if cr then
      gotoxy(21,11)
    else
      gotoxy(21,12);
    for x:=1 to 1Ø do
    begin
      for y:=1 to 3 do write(nd.opplist[x,y]);
      if x<>1Ø then write(', ')
    end;
  end
  else
    write(tempst2,nd);
  if not(foundtext) then write('not found');
end;
```

```
                              (*       amend text codes          *)
procedure ammcode(a1,b1,a2,b2,max:integer;f1:boolean);
var s,t,x,acount:integer;
    ch:char;
    ac:str3;
    err:boolean;
begin
  if f1=true then
    s:=3;t:=1
  else
  begin
    s:=21;t:=1
  end;
  acount:=0;
  repeat
    err:=false;
    acount:=acount+1;
    gotoxy(s,t);
    getkey('001',a1,b1,a2,b2,s,t,ch);
    if ch=£0 then ch:=readkey;
    case ord(ch) of
      13 : begin
             if f1 then
               t:=t+1
             else
             begin
               s:=s+5;
               if acount=10 then
               begin
                 s:=21;
                 t:=2;
               end
             end
           end;
      27 : begin
             (* no action *)
           end
      else
      begin
        if ch in ['1','2','3','4','5','6','7','8','9','0'] then
        begin
          write(ch);
          ac[1]:=ch;
          getkey('001',a1,b1,a2,b2,wherex,wherey,ch);
          if ch in ['1','2','3','4','5','6','7','8','9','0'] then
          begin
            write(ch);
            ac[2]:=ch;
            getkey('001',a1,b1,a2,b2,wherex,wherey,ch);
            if ch in ['1','2','3','4','5','6','7','8','9','0'] then
            begin
              write(ch);
              ac[3]:=ch;
              s:=s+5
            end
            else
            begin
              errmess('434');
              err:=true
            end
          end
```

```
          else
          begin
            errmess('435');
            err:=true
          end
        end
        else
        begin
          errmess('436');
          err:=true
        end
      end
    end;
    if err=false then
    begin
      if f1 then
        for x:=1 to 3 do st.ndstacode[x]:=ac[x]
      else
      begin
        if acount>10 then
        for x:=1 to 3 do nd.opplist[acount-10,x]:=ac[x]
        else
          for x:=1 to 3 do nd.samelist[acount,x]:=ac[x]
      end
    end
  until ((acount=max) or (ord(ch)=27)) and not err;
end;

                                (* display screen of text and    *)
                                (* codes to amend                *)
procedure clinirules;
var nextr,amm,de,escout,refb:boolean;
    ac1,ac:str3;
    count,contrl,x,y,same:integer;
begin
  refb:=false;
  escout:=false;
  reset(stage1);
  reset(stage2);
  repeat
    nextr:=false;
    scrout('010',clintext);
    messout;
    window(2,8,79,23);
    get_return('001');
    contrl:=1;
    count:=10;
    while not eof(stage1) and not eof(stage2) and not(escout) do
    begin
      clrscr;
      case contrl of
        1 :  scrout('021',clintext);
        2 :  scrout('022',clintext)
      end;
      messout;
      window(2,8,79,23);
      count:=3;
```

```
for z:=1 to count do
begin
  gotoxy(60,8+z);
  read(stage1,st);
  for x:=1 to 3 do write(st.ndstacode[x]);
end;
setwindow(58,16,66,19);
ammcode(58,16,66,19,3,true);
window(2,8,79,23);
gotoxy(10,13);
writemess('213');
getkey('001',2,8,79,23,10,13,ch);
if ch=£0 then ch:=readkey;
case ord(ch) of
  13:begin
       nextr:=true(**);
       contrl:=contrl+1
     end;
  27:escout:=true;
  else
  begin
    repeat
      clrscr;
      scrout('035',clintext);
      messout;
      window(2,8,79,23);
      gotoxy(1,5);
      if refb then
        puttexton(false,ac1,stadvice)
      else
        readcode(false,ch,ac1,stadvice);
      window(2,8,79,23);
      writerules(true,ac1);
      window(2,17,79,18);
      ammcode(2,17,79,18,20,false);
      window(2,8,79,23);
      gotoxy(2,13);
      writemess('349');
      getkey('001',2,8,79,23,2,13,ch);
      case ord(ch) of
        13 : (* return back *);
        27 : escout:=true;
        else
        begin
          clrscr;
          scrout('040',clintext);
          messout;
          window(2,8,79,23);
          readcode(false,ch,ac,ndadvice);
          window(2,16,79,19);
          clrscr;
          window(2,8,79,23);
          gotoxy(15,13);
          writemess('350');
          getkey('001',2,8,79,23,15,13,ch);
          case ord(ch) of
            13 : refb:=true;
            27 : escout:=true;
          end;
        end;
        window(2,8,79,23)
```

```
            end
          until escout
        end;
      end;
    end
  until escout or eof(stage1)
end;

                                (*          amend text          *)
procedure ruletext;
var amm,de,escout,refb,rep,ret:boolean;
    ac1,ac:str3;
    x,y,same:integer;
begin
  refb:=false;
  escout:=false;
  reset(stage1);
  reset(stage2);
  scrout('Ø15',clintext);
  messout;
  window(2,8,79,23);
  get_return('ØØ1');
  while not eof(stage1) and not eof(stage2) and not(escout) do
  begin
    repeat
      ret:=false;
      clrscr;
      scrout('Ø2Ø',clintext);
      messout;
      window(2,8,79,23);
      for z:=1 to 3 do
      begin
        gotoxy(6Ø,6+z);
        read(stage1,st);
        for x:=1 to 3 do write(st.ndstacode[x]);
      end;
      window(2,8,79,23);
      gotoxy(25,13);
      writemess('351');
      getkey('ØØ1',2,8,79,23,25,13,ch);
      if ch=£Ø then ch:=readkey;
      case ord(ch) of
        13:ret:=true;
        27:escout:=true;
        else
        begin
          repeat
            clrscr;
            scrout('Ø37',clintext);
            messout;
            window(2,8,79,23);
            gotoxy(1,5);
            if refb then puttexton(true,ac1,stadvice)
            else
              readcode(true,ch,ac1,stadvice);
            window(2,8,79,23);
            writerules(false,ac1);
            gotoxy(2,13);
            writemess('353');
            getkey('ØØ1',2,8,79,23,2,13,ch);
```

```
        case ord(ch) of
          13 : ret:=true;
          27 : escout:=true;
          97 : begin
                 amm:=true;
                 ammendordel(ac1,amm,stadvice);
                 escout:=false;
                 refb:=true
               end;
         100 : begin
                 amm:=false;
                 ammendordel(ac1,amm,stadvice);
                 escout:=false;
                 refb:=true
               end;
          else
          begin
            rep:=false;
            repeat
              refb:=true;
              clrscr;
              scrout('040',clintext);
              messout;
              window(2,8,79,23);
              if rep=true then
                puttexton(true,ac,ndadvice)
              else
                readcode(true,ch,ac,ndadvice);
              window(2,8,79,23);
              gotoxy(10,13);
              writemess('354');
              getkey('001',2,8,79,23,10,13,ch);
              case ord(ch) of
                13 : ret:=true;
                27 : escout:=true;
                97 : begin
                       amm:=true;
                       ammendordel(ac,amm,ndadvice);
                       rep:=true
                     end;
               100 : begin
                       amm:=false;
                       ammendordel(ac,amm,ndadvice);
                       rep:=true
                     end;
              end;
            until escout or (ord(ch)=13)
          end;
          window(2,8,79,23)
        end
      until escout  or (ord(ch)=13)
    end;
  end;
until ret or escout
end;
end;
```

```
                              (*        read  a number         *)
procedure numin(a1,b1,a2,b2,x,y:integer;ch:char;
                     var numbar:integer;var valnum:boolean);
begin
  if (ord(ch)<58) and (ord(ch)>47) then
  begin
    numbar:=ord(ch)-48;
    getkey('ØØ1',a1,b1,a2,b2,x,y,ch);
    if (ord(ch)<58) and (ord(ch)>47) then
    begin
      numbar:=(numbar*1Ø)+(ord(ch)-48);
      write(numbar)
    end
    else
      valnum:=false
  end
  else
    valnum:=false;
  if not valnum then errmess('355')
end;

                              (* print headings for complete  *)
                              (* insulin, text and code       *)
                              (* hard copy report             *)
procedure oprint(ac:str3;var filen:text);
var ch:char;
    x,ct:integer;
begin
  reset(filen);
  ct:=Ø;
  read(filen,ch);
  repeat
    ct:=Ø;
    for x:=1 to 3 do
    begin
      read(filen,ch);
      if ac[x]=ch then ct:=ct+1
    end;
    read(filen,ch);
    if ct<>3 then
    begin
      repeat
        read(filen,ch)
      until (ch='"') or eof(filen)
    end
  until (ct=3) or eof(filen);
  if ct=3 then
  begin
    repeat
      read(filen,ch);
      if (ch<>'"') and not eof(filen) then write(lst,ch)
    until (ch='"') or eof(filen);
  end;
end;
```

```
                                    (*   print text codes and text   *)
procedure printcodetext;
var same,z,x,y:integer;
    ch:char;
    tok:str3;
begin
  reset(stage1);
  window(1,1,80,24);
  oprint('025',clintext);
  for z:=1 to 3 do
  begin
    read(stage1,st);
    gotoxy(63,8+z);
    for x:= 1 to 3 do
      write(lst,st.ndstacode[x]);
  end;
  for x:= 1 to 6 do writeln(lst);
  reset(stage1);
  read(stage1,st);
  for x:=1 to 3 do tok[x]:=st.ndstacode[x];
  for z:=1 to 1 do
  begin
    window(1,1,80,24);
    for x:=1 to 3 do write(lst,tok[x]);
    writeln;
    oprint(tok,stadvice);
    for x:=1 to 6 do writeln(lst);
    reset(stage2);
    same:=0;
    if not eof(stage2) then  read(stage2,nd);
    for x:=1 to 3 do if tok[x]=nd.acode[x] then same:=same+1;
    if same=3 then
    begin
      for x:=1 to 10 do
      begin
        for y:=1 to 3 do write(lst,nd.samelist[x,y]);
        if x<>10 then write(lst,', ')
      end;
      writeln(lst);
      for x:=1 to 10 do
      begin
        for y:=1 to 3 do write(lst,nd.opplist[x,y]);
        if x<>10 then write(lst,', ')
      end
    end
    else
      if not eof(stage2) then  read(stage2,nd);
  end;
  window(1,1,80,24);
  reset(ndadvice);
  while not eof(ndadvice) do
  begin
    read(ndadvice,ch);
    write(lst,ch)
  end;
  window(1,1,80,24);
end;
```

```
                                    (*  amend insulin detail file    *)
procedure insfch;
var  ic,a,d,x,y,insno,n1,n2: integer;
     errval,errfil,amm,escout,valnum,cherr:boolean;
     insarr:packed array[1..30] of char;
begin
  assign(clintext,'b:clintext.txt');
  assign(tempins,'b:tempins.dat');
  escout:=false;
  assign(inst,'b:inst.txt');
  assign(insfile,'b:insfile.dat');
  reset(insfile);
  ic:=0;
  repeat
    repeat
      clrscr;
      scrout('050',clintext);
      messout;
      window(2,8,79,23);
      a:=6; d:=5; y:=0;
      while not eof(insfile) and (y<4)  do
      begin
        ic:=ic+1;
        d:=d+1;
        y:=y+1;
        gotoxy(a,d);
        read(insfile,insrec);
        if ic<10 then
          write('0',ic)
        else
          write(ic);
        gotoxy(13,d);
        for x:=1 to 30 do
        begin
          gotoxy(13+x,d);
          write(insrec.brand[x]);
        end;
        gotoxy(50,d);
        write(insrec.onset);
        gotoxy(66,d);
        write(insrec.endaction);
        writeln
      end;
      repeat
        errval:=false;
        gotoxy(14,12);
        writemess('356');
        getkey('001',2,8,79,23,14,12,ch);
        write(ch);
        gotoxy(14,12);
        writeln;
        if ch=£0 then ch:=readkey;
        case ord(ch) of
          63,97 : begin
                    amm:=true;
                    gotoxy(25,12);
                    writemess('357')
                  end;
```

```
      66,100 : begin
                 amm:=false;
                 gotoxy(25,12);
                 writemess('358')
               end;
         27  : escout:=true;
         13  : retval
       else
         begin
           errval:=true
         end
     end;
   until errval=false
until (ord(ch)<>13) or eof(insfile);
if not(escout) and not eof(insfile) then
begin
  reset(insfile);
  rewrite(tempins);
  repeat
    errfil:=false;
    repeat
      valnum:=true;
      gotoxy(49,12);
      getkey('001',2,8,79,23,49,12,ch);
      numin(2,8,79,23,49,12,ch,insno,valnum);
    until valnum=true;
    for x:=1 to (insno-1) do
    begin
      if not eof(insfile) then read(insfile,insrec);
      if eof(insfile) then errfil:=true;
      write(tempins,insrec);
    end;
  until errfil=false;
  if not eof(insfile) and (amm=false) then read(insfile,insrec);
  if amm then
  begin
    x:=1;
    gotoxy(20,12);
    write('                ');
    gotoxy(10,12);
    writemess('358');
    repeat
      repeat
        cherr:=false;
        gotoxy(35+x,12);
        getkey('001',2,8,79,23,35+x,12,ch);
        write(ch);
        if ord(ch)<>27 then
        begin
          if ((ord(ch)>64) and (ord(ch)<91)) or
             ((ord(ch)>96) and (ord(ch)<123)) then
          begin
            insarr[x]:=ch;
            gotoxy(35+x,12);
            write(insarr[x])
          end
          else
```

```
            begin
             errmess('29');
             cherr:=true
            end
          end
        until (cherr=false) or (ord(ch)=27);
        x:=x+1
      until (x=31) or (ord(ch)=27);
      for y:=(x-1) to 30 do insarr[y]:=' ';
      gotoxy(10,12);
      writeln;
      gotoxy(15,12);
      writemess('358');
      repeat
        valnum:=true;
        gotoxy(31,12);
        getkey('001',2,8,79,23,31,12,ch);
        numin(2,8,79,23,31,12,ch,n1,valnum);
      until valnum;
      repeat
        valnum:=true;
        gotoxy(62,12);
        getkey('001',2,8,79,23,62,12,ch);
        numin(2,8,79,23,62,12,ch,n2,valnum);
      until valnum;
      for x:=1 to 30 do insrec.brand[x]:=insarr[x];
      insrec.onset:=n1;
      insrec.endaction:=n2;
      write(tempins,insrec);
    end;
    while not eof(insfile) do
    begin
      read(insfile,insrec);
      write(tempins,insrec);
    end;
    reset(tempins);
    rewrite(insfile);
    while not eof(tempins) do
    begin
      read(tempins,insrec);
      write(insfile,insrec);
    end;
  end;
 until eof(insfile) or escout;
 close(insfile);
 get_return('001')
end;
```

```
(****************************************************************)
(*                                                              *)
(*                    PRINT DIARY MODULE                        *)
(*                                                              *)
(****************************************************************)

procedure writeheader(tok1:str3;var filen:text);
var ch:char;
    same,x,y:integer;
begin
end;

procedure printdiary;
var notes,foundrec:boolean;
    x,y:integer;
begin
  window(2,8,79,23);
  clrscr;
  scrout('Ø84',inscreens);
  reset(bloodf);
  oprint('Ø8Ø',inscreens);
  while not eof(bloodf) do
  begin
    notes:=false;
    foundrec:=false;
    read(bloodf,brec);
    writeln;
    write(lst,brec.bd[3],'.',brec.bd[2],'.',brec.bd[1],'    ');
    if brec.bth[1]=Ø then
      write(lst,'         ')
    else
      write(lst,brec.bth[1],'.',brec.btm[1],'  ',brec.br[1]);
    reset(urinef);
    while not eof(urinef) and not(foundrec) do
    begin
      read(urinef,urec);
      finddate(urec.ud,brec.bd,foundrec);
    end;
    if foundrec then
    begin
      for x:=1 to 4 do write(lst,urec.ur[x],' ');
      foundrec:=false
    end
    else
      write(lst,'         ');
    foundrec:=false;
    reset(dietf);
    while not eof(dietf) and not(foundrec) do
    begin
      read(dietf,drec);
      finddate(drec.dd,brec.bd,foundrec);
    end;
    if foundrec then
    begin
      gotoxy(42,8);
      for x:=1 to 6 do write(lst,drec.cho[x],' ');
      foundrec:=false
    end;
    writeln(lst);
```

```
for x:=2 to 6 do
begin
  if brec.bth[x]<>Ø then
  begin
    write(lst,'              ');
    write(lst,brec.bth[x],'.',brec.btm[x],brec.br[x]:3);
  end
end;
oprint('Ø82',inscreens);
reset(hypof);
while not eof(hypof) and not(foundrec) do
begin
  read(hypof,hyrec);
  finddate(hyrec.hyd,brec.bd,foundrec);
end;
if foundrec then
begin
  notes:=true;
  writelst('1Ø');
  for x:=1 to 6 do
  if hyrec.ht[1,x]<>Ø then write(lst,hyrec.ht[1,x],'.',
                                     hyrec.ht[2,x],'  ');
  foundrec:=false;
end;
writeln(lst);
reset(exerf);
while not eof(exerf) and not(foundrec) do
begin
  read(exerf,exrec);
  finddate(exrec.ed,brec.bd,foundrec);
end;
if foundrec then
begin
  writelst('11');
  if not(notes) then oprint('Ø81',inscreens);
  writeln;
  case exrec.etype of
    1 : writelst('12');
    2 : writelst('13');
    3 : writelst('14')
  end;
  write(lst,' from ',exrec.etime[1,1],'.',exrec.etime[1,2]);
  write(lst,' to ',exrec.etime[2,1],'.',exrec.etime[2,2]);
end;
reset(emotf);
while not eof(emotf) and not(foundrec) do
begin
  read(emotf,emrec);
  finddate(emrec.emd,brec.bd,foundrec)
end;
if foundrec then
begin
  writeln(lst);
  writelst('15');
  if emrec.emtype[1]='y' then writelst('16');
  if emrec.emtype[2]='y' then writelst('17');
  if emrec.emtype[3]='y' then writelst('18');
  if emrec.emtype[4]='y' then writelst('19');
  foundrec:=false
end;
```

```
    reset(healf);
    while not eof(healf) and not(foundrec) do
    begin
      read(healf,herec);
      finddate(herec.hed,brec.bd,foundrec)
    end;
    if foundrec then
    begin
      writeln(lst);
      writelst('2Ø');
      if herec.htype[1]='y' then writelst('21');
      if herec.htype[2]='y' then writelst('22');
      if herec.htype[3]='y' then writelst('23');
      if herec.htype[4]='y' then writelst('24');
      if herec.htype[5]='y' then writelst('25');
      if herec.htype[6]='y' then writelst('26');
      foundrec:=false
    end;
    reset(holsf);
    while not eof(holsf) and not(foundrec) do
    begin
      read(holsf,horec);
      finddate(horec.hod,brec.bd,foundrec)
    end;
    if foundrec then
    begin
      writelnlst('27');
      foundrec:=false
    end;
    while not eof(notesf) and not(foundrec) do
    begin
      read(notesf,norec);
      finddate(norec.nod,foundrec)
    end;
    if foundrec then
    begin
      if not(notes) then scrout('Ø81',inscreens);
      for x:=1 to 7Ø do
      begin
        for y:=1 to 4 do
          write(norec.extras[x,y]);
        writeln
      end;
      foundrec:=false
    end;
    oprint('Ø81',inscreens);
  end;
  oprint('Ø83',inscreens);
  clrscr;
  scrout('Ø85',inscreens);
  get_return('ØØ1');
  window(1,1,8Ø,24);
  clrscr;
  setscreenup
end;
```

```
(*                                                              *)
(*                       MAIN PROGRAM                           *)
(*                                                              *)
begin
  initialise;
  setscreenup;
  menuØ;
  quitout:=false;
  repeat
    clinmenu1
  until quitout=true;
end.
```

APPENDIX VI

ADVICE TEXT

"111"

Advice : Identify the times when the hypos occur.
Explore the possibilities of exercise such as running home from school etc as being a cause of the problem.
Ensure that carbohydrate is taken regularly.
If you are unsure then contact your health visitor.

Reason : The hypos do not occur regularly and therefore it may not be necessary to adjust your insulin dose.

"121"

Advice : Identify the times when the hypos occur.
Explore the possibilities of exercise such as running home from school etc as being a cause of the problem.
Ensure that carbohydrate is taken regularly.
If you are unsure then contact your health visitor.

Reason : The times of the hypos are difficult to identify and it may be necessary to adjust more than one dose.

"131"

Advice : You should eat some extra carbohydrate before you exercise.

Reason : The hypos occur after exercise and therefore you are not eating enough carbohydrate beforehand to provide the energy you need.

"141"

Advice : You should not miss your meal or snack.

Reason : The hypos occurred after you had missed your meal or snack. Your body did not have enough carbohydrate resulting in your blood glucose levels falling and a hypo occurring.

"151"

Advice : Increase your carbohydrate allowance by 10g. The extra 10g should be added to the last meal or snack eaten before the hypos occur.

Reason : You have grown since your last increase in carbohydrate allowance. Your body uses energy/carbohydrate to grow and therefore as you grow your carbohydrate allowance should be increased

"161"

Advice : Your insulin dose should be adjusted.

Reason : The hypos you are experiencing are persistent and they occur at particular times. It is unlikely that they are due to exercise or too little carbohydrate and therefore it is likely that your insulin dose is too high.

"211"

Advice : Do not eat extra carbohydrate between meals unless it is before exercise.Ensure that if extra carbohydrate is eaten before exercise it is not too much.

Reason : You may have mistakenly eaten a little too much carbohydrate resulting in the odd high test result.

"221"

Advice : Do not eat extra carbohydrate between meals unless it is before exercise.Ensure that if extra carbohydrate is eaten before exercise it is not too much.Try to identify the times when they occur the most and then use this option again.If you are worried about this problem then contact your health visitor or doctor.

Reason : The high test results do not occur at particular times and it is therefore difficult to identify the cause.

"231"

Advice : Reduce the quantity of carbohydrate eaten before exercise.

Reason : The high test results occur after exercise and because you eat extra carbohydrate prior to the exercise it is likely that you are eating to much for the exercise being performed.Your body is probably not using up all the extra carbohydrate resulting in high blood glucose levels and high blood test results.

"241"

Advice : Do not eat extra carbohydrate to that which the dietician advised.

Reason : The extra carbohydrate that you have eaten has not been used up by your body to provide energy resulting in high blood glucose and high test results.

"251"

Advice : Decrease your carbohydrate allowance by 10g.

Reason : You may have increased your allowance too much resulting in high test results.

"261"

Advice : Your insulin dose should be adjusted.

Reason : Your high test results are persistent and occur at a particular time.It is unlikely that they are due to exercise or too much carbohydrate and therefore your insulin dose might be the cause.

"111"
Advice : Increase your pre breakfast quick acting insulin by 2 units.

Reason : Your high test results at the time when the quick acting insulin is most active.

"112"
Advice : Increase your pre breakfast intermediate insulin 2 units.

Reason : Your high test results at the time when the intermediate insulin is most active.

"113"
Advice : Increase your pre breakfast long acting insulin by 2 units.

Reason : Your high test results at the time when the long acting insulin is most active.

"121"
Advice : Increase your pre lunch quick acting insulin by 2 units.

Reason : Your high blood test results occur at the time when the quick acting insulin is most active.

"122"
Advice : Increase your pre lunch intermediate insulin by 2 units.

Reason : Your high blood test results occur at the time when the intermediate insulin is most active.

"123"
Advice : Increase your pre lunch long acting insulin by 2 units.

Reason : Your high blood test results occur at the time when the long acting insulin is most active.

"131"
Advice : Increase your pre tea quick acting insulin by 2 units.

Reason : Your high blood test results occur at the time when the quick acting insulin is most active.

"132"
Advice : Increase your pre tea intermediate insulin by 2 units.

Reason : Your high blood test results occur at the time when the intermediate insulin is most active.

"133"
Advice : Increase your pre tea long acting insulin by 2 units.

Reason : Your high blood test results occur at the time when the long acting insulin is most active.

"141"
Advice : Increase your pre dinner quick acting insulin by 2 units.

Reason : Your high blood test results occur at the time when the quick acting insulin is most active.

"142"
Advice : Increase your pre dinner intermediate insulin by 2 units.

Reason : Your high blood test results occur at the time when the intermediate insulin is most active.

"143"
Advice : Increase your pre dinner long acting insulin by 2 units.

Reason : Your high blood test results occur at the time when the long acting insulin is at its most effective.
"151"
Advice : Increase your evening quick acting insulin by 2 units.

Reason : Your high blood test results occur at the time when the quick acting insulin is at its most effective.
"152"
Advice : Increase your evening intermediate insulin by 2 units.

Reason : Your high blood test results occur at the time when the intermediate insulin is at its most effective.
"153"
Advice : Increase your évening long acting insulin by 2 units.

Reason : Your high blood test results occur at the time when the long actin insulin is at its most effective.
"211"
Advice : Decrease your pre breakfast quick acting insulin by 2 units.

Reason : Your hypos occur at the time when the quick acting insulin is most active.
"212"
Advice : Decrease your pre breakfast intermediate insulin 2 units.

Reason : Your hypos at the time when the intermediate insulin is most active.
"213"
Advice : Decrease your pre breakfast long acting insulin by 2 units.

Reason : Your hypos at the time when the long acting insulin is most active.
"221"
Advice : Decrease your pre lunch quick acting insulin by 2 units.

Reason : Your hypos occur at the time when the quick acting insulin is most active.
"222"
Advice : Decrease your pre lunch intermediate insulin by 2 units.

Reason : Your hypos occur at the time when the intermediate insulin is most active.
"223"
Advice : Decrease your pre lunch long acting insulin by 2 units.

Reason : Your hypos occur at the time when the long acting insulin is most active.
"231"
Advice : Decrease your pre tea quick acting insulin by 2 units.

Reason : Your hypos occur at the time when the quick acting insulin is most active.

"232"
Advice : Decrease your pre tea intermediate insulin by 2 units.

Reason : Your hypos occur at the time when the intermediate insulin is most active.

"233"
Advice : Decrease your pre tea long acting insulin by 2 units.

Reason : Your hypos occur at the time when the long acting insulin is most active.

"241"
Advice : Decrease your pre dinner quick acting insulin by 2 units.

Reason : Your hypos occur at the time when the quick acting insulin is most active.

"242"
Advice : Decrease your pre dinner intermediate insulin by 2 units.

Reason : Your hypos occur at the time when the intermediate insulin is most active.

"243"
Advice : Decrease your pre dinner long acting insulin by 2 units.

Reason : Your hypos occur at the time when the long acting insulin is at its most effective.

"251"
Advice : Decrease your evening quick acting insulin by 2 units.

Reason : Your hypos occur at the time when the quick acting insulin is at its most effective.

"252"
Advice : Decrease your evening intermediate insulin by 2 units.

Reason : Your hypos occur at the time when the intermediate insulin is at its most effective.

"253"
Advice : Decrease your evening long acting insulin by 2 units.

Reason : Your hypos occur at the time when the long actin insulin is at its most effective.

"ØØ1"
Advice : Increase your pre breakfast quick acting insulin by 2 units.

Reason : The original decrease was probably too much.
"ØØ2"
Advice : Increase your pre breakfast intermediate insulin by 2 units.

Reason : The original decrease was probably too much.
"ØØ3"
Advice : Increase your pre breakfast long acting insulin by 2 units.

Reason : The original decrease was probably too much.
"ØØ4"
Advice : Increase your pre lunch quick acting insulin by 2 units.

Reason : The original decrease was probably too much.
"ØØ5"
Advice : Increase your pre lunch intermediate insulin by 2 units.

Reason : The original decrease was probably too much.
"ØØ6"
Advice : Increase your pre lunch long acting insulin by 2 units.

Reason : The original decrease was probably too much.
"ØØ7"
Advice : Increase your pre tea quick acting insulin by 2 units.

Reason : The original decrease was probably too much.
"ØØ8"
Advice : Increase your pre tea intermediate insulin by 2 units.

Reason : The original decrease was probably too much.
"ØØ9"
Advice : Increase your pre tea long acting insulin by 2 units.

Reason : The original decrease was probably too much.
"Ø1Ø"
Advice : Increase your pre dinner quick acting insulin by 2 units.

Reason : The original decrease was probably too much.
"Ø11"
Advice : Increase your pre dinner intermediate insulin by 2 units.

Reason : The original decrease was probably too much.
"Ø12"
Advice : Increase your pre dinner long acting insulin by 2 units.

Reason : The original decrease was probably too much.
"Ø13"
Advice : Increase your evening quick acting insulin by 2 units.

Reason : The original decrease was probably too much.

"Ø14"
Advice : Increase your evening intermediate insulin by 2 units.

Reason : The original decrease was probably too much.
"Ø15"
Advice : Increase your evening long acting insulin by 2 units.

Reason : The original decrease was probably too much.
"Ø16"
Advice : Decrease your pre breakfast quick acting insulin by 2 units.

Reason : The original increase was probably too much.
"Ø17"
Advice : Decrease your pre breakfast intermediate insulin by 2 units.

Reason : The original increase was probably too much.
"Ø18"
Advice : Decrease your pre breakfast long acting insulin by 2 units.

Reason : The original increase was probably too much.
"Ø19"
Advice : Decrease your pre lunch quick acting insulin by 2 units.

Reason : The original increase was probably too much.
"Ø2Ø"
Advice : Decrease your pre lunch intermediate insulin by 2 units.

Reason : The original increase was probably too much.
"Ø21"
Advice : Decrease your pre lunch long acting insulin by 2 units.

Reason : The original increase was probably too much.
"Ø22"
Advice : Decrease your pre tea quick acting insulin by 2 units.

Reason : The original increase was probably too much.
"Ø23"
Advice : Decrease your pre tea intermediate insulin by 2 units.

Reason : The original increase was probably too much.
"Ø24"
Advice : Decrease your pre tea long acting insulin by 2 units.

Reason : The original increase was probably too much.
"Ø25"
Advice : Decrease your pre dinner quick acting insulin by 2 units.

Reason : The original increase was probably too much.
"Ø26"
Advice : Decrease your pre dinner intermediate insulin by 2 units.

Reason : The original increase was probably too much.
"Ø27"
Advice : Decrease your pre dinner long acting insulin by 2 units.

Reason : The original increase was probably too much.

"Ø28"
Advice : Decrease your evening quick acting insulin by 2 units.

Reason : The original increase was probably too much.
"Ø29"
Advice : Decrease your evening intermediate insulin by 2 units.

Reason : The original increase was probably too much.
"Ø3Ø"
Advice : Decrease your evening long acting insulin by 2 units.

Reason : The original increase was probably too much.
"Ø31"
Advice : Decrease your pre breakfast quick acting insulin by 2 units.

Reason : The original decrease was probably too little.
"Ø32"
Advice : Decrease your pre breakfast intermediate insulin by 2 units.

Reason : The original decrease was probably too little.
"Ø33"
Advice : Decrease your pre breakfast long acting insulin by 2 units.

Reason : The original decrease was probably too little.
"Ø34"
Advice : Decrease your pre lunch quick acting insulin by 2 units.

Reason : The original decrease was probably too little.
"Ø35"
Advice : Decrease your pre lunch intermediate insulin by 2 units.

Reason : The original decrease was probably too little.
"Ø36"
Advice : Decrease your pre lunch long acting insulin by 2 units.

Reason : The original decrease was probably too little.
"Ø37"
Advice : Decrease your pre tea quick acting insulin by 2 units.

Reason : The original decrease was probably too little.
"Ø38"
Advice : Decrease your pre tea intermediate insulin by 2 units.

Reason : The original decrease was probably too little.
"Ø39"
Advice : Decrease your pre tea long acting insulin by 2 units.

Reason : The original decrease was probably too little.
"Ø4Ø"
Advice : Decrease your pre dinner quick acting insulin by 2 units.

Reason : The original decrease was probably too little.
"Ø41"
Advice : Decrease your pre dinner intermediate insulin by 2 units.

Reason : The original decrease was probably too little.

"Ø42"
Advice : Decrease your pre dinner long acting insulin by 2 units.

Reason : The original decrease was probably too little.
"Ø43"
Advice : Decrease your evening quick acting insulin by 2 units.

Reason : The original decrease was probably too little.
"Ø44"
Advice : Decrease your evening intermediate insulin by 2 units.

Reason : The original decrease was probably too little.
"Ø45"
Advice : Decrease your evening long acting insulin by 2 units.

Reason : The original decrease was probably too little.
"Ø46"
Advice : Increase your pre breakfast quick acting insulin by 2 units.

Reason : The original increase was probably too little.
"Ø47"
Advice : Increase your pre breakfast intermediate insulin by 2 units.

Reason : The original increase was probably too little.
"Ø48"
Advice : Increase your pre breakfast long acting insulin by 2 units.

Reason : The original increase was probably too little.
"Ø49"
Advice : Increase your pre lunch quick acting insulin by 2 units.

Reason : The original increase was probably too little.
"Ø5Ø"
Advice : Increase your pre lunch intermediate insulin by 2 units.

Reason : The original increase was probably too little.
"Ø51"
Advice : Increase your pre lunch long acting insulin by 2 units.

Reason : The original increase was probably too little.
"Ø52"
Advice : Increase your pre tea quick acting insulin by 2 units.

Reason : The original increase was probably too little.
"Ø53"
Advice : Increase your pre tea intermediate insulin by 2 units.

Reason : The original increase was probably too little.
"Ø54"
Advice : Increase your pre tea long acting insulin by 2 units.

Reason : The original increase was probably too little.
"Ø55"
Advice : Increase your pre dinner quick acting insulin by 2 units.

Reason : The original increase was probably too little.

"Ø56"
Advice : Increase your pre dinner intermediate insulin by 2 units.

Reason : The original increase was probably too little.
"Ø57"
Advice : Increase your pre dinner long acting insulin by 2 units.

Reason : The original increase was probably too little.
"Ø58"
Advice : Increase your evening quick acting insulin by 2 units.

Reason : The original increase was probably too little.
"Ø59"
Advice : Increase your evening intermediate insulin by 2 units.

Reason : The original increase was probably too little.
"Ø6Ø"
Advice : Increase your evening long acting insulin by 2 units.

Reason : The origginal increase was probably too little.
"Ø61"
Advice : Decrease the carbohydrate of the last meal before the high test results by 1Øg and increase the last insulin change by 2 units.

Reason : Your high test results may be due to too much carbohydrate.
"Ø62"
Advice : Increase the carbohydrate of the last meal before the hypos by 1Øg and decrease the last insulin change by 2 units.

Reason : Your hypos may be due to too little carbohydrate.
"Ø63"
Advice : Eat the last meal or snack before the hypos occur earlier.

Reason : Your hypos occur just before a meal/snack and your blood glucose is dipping a little low.
"Ø64"
Advice : Delay your evening injection and meal by 3Ø minutes.

Reason : Your evening injection is not lasting long enough to prevent high test results in the morning.
"Ø65"
Advice : Increase the carbohydrate of the last meal before the hypos by 1Øg and increase the last insulin change by 2 units.

Reason : Your hypos may be due to too little carbohydrate.
"Ø7Ø"
Advice : Increase pre breakfast intermediate insulin by 2 units.
Decrease pre lunch intermediate insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø71"
Advice : Increase pre lunch intermediate insulin by 2 units.
Decrease pre tea intermediate insulin by 2 units.

Reason : The initial insulin change was probably incorrect.

"Ø72"
Advice : Increase pre tea intermediate insulin by 2 units.
Decrease pre dinner intermediate insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø73"
Advice : Increase pre dinner intermediate insulin by 2 units.
Decrease pre breakfast intermediate insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø74"
Advice : Increase pre breakfast quick acting insulin by 2 units.
Decrease pre breakfast long acting insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø75"
Advice : Increase pre breakfast long acting insulin by 2 units.
Decrease pre breakfast quick acting insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø76"
Advice : Increase evening quick acting insulin by 2 units.
Decrease evening long acting insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø77"
Advice : Increase evening long acting insulin by 2 units.
Decrease evening quick acting insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø78"
Advice : Increase evening long acting insulin by 2 units.
Decrease pre breakfast quick acting insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø79"
Advice : Increase pre breakfast quick acting insulin by 2 units.
Decrease evening long acting insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø8Ø"
Advice : Increase pre breakfast intermediate insulin by 2 units.
Decrease evening intermediate insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø81"
Advice : Increase evening intermediate insulin by 2 units.
Decrease pre breakfast intermediate insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø82"
Advice : Deccrease pre breakfast intermediate insulin by 2 units.
Increase pre lunch intermediate insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø83"
Advice : Decrease pre lunch intermediate insulin by 2 units.
Increase pre tea intermediate insulin by 2 units.

Reason : The initial insulin change wwas probably incorrect.

"Ø84"
Advice : Decrease pre tea intermediate insulin by 2 units.
Increase pre dinner intermediate insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø85"
Advice : Decrease pre dinner intermediate insulin by 2 units.
Increase pre breakfast intermediate insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø86"
Advice : Decrease pre breakfast long acting insulin by 2 units.
Increase pre breakfast quick acting insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø87"
Advice : Decrease pre breakfast long acting insulin by 2 units.
Increase pre breakfast quick acting insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø88"
Advice : Decrease evening quick acting insulin by 2 units.
Increase evening long acting insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø89"
Advice : Decrease evening long acting insulin by 2 units.
Increase evening quick acting insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø9Ø"
Advice : Decrease evening long acting insulin by 2 units.
Increase pre breakfast quick acting insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø91"
Advice : Decrease pre breakfast quick acting insulin by 2 units.
Increase evening long acting insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø92"
Advice : Increase evening quick acting insulin by 2 units.
Decrease pre breakfast long acting insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø93"
Advice : Increase evening long acting insulin by 2 units.
Decrease evening quick insulin by 2 units.

Reason : The initial insulin changee was probably incorrect.
"Ø94"
Advice : Decrease evening quick acting insulin by 2 units.
Increase pre breakfast long acting insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø95"
Advice : Decrease evening long acting insulin by 2 units.
Increase evening intermediate insulin by 2 units.

Reason : The initial insulin change was probably incorrect.

"Ø96"
Advice : Decrease pre breakfast intermediate insulin by 2 units.
Increase evening intermediate insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"Ø97"
Advice : Decrease evening intermediate insulin by 2 units.
Increase pre breakfast intermediate insulin by 2 units.

Reason : The initial insulin change was probably incorrect.
"998"
Advice : Contact your health visitor or doctor about this problem.

Reason : You have taken the necessary steps to solve this problem
but your high test results persist.
"999"
Advice : Contact your health visitor or doctor about this problem.

Reason : You have taken the necessary steps to solve this problem
but your hypos persist.

APPENDIX VII

HELP TEXT

"OOO"

{HELP}

START OF HELP

Do not page back - forward or ESC only

"ØØ1"

Introduction {HELP}

This system aims to help you learn about your condition, diabetes. You can save all the information about your blood tests, health etc that you would normally enter into your diary. The diabetic management system can also help you decide whether you should alter your insulin dose. If you need general information about diabetes then ther is a section available. Always remember that the system aims to assist you in maintaining good blood sugar control. If you are ill or unsure about your treatment you should always ask your health visitor or doctor.
The next page of help gives information about the keys needed to operate the system.

"ØØ2"

System Keys {HELP}

The keys you will need to use to control the system are :

keys	position
arrows	left hand side of keyboard
ESC	left hand side of keyboard
DEL	bottom right hand side of keyboard
RETURN	right hand side of keyboard
F1	top left hand side of keyboard

The following page explains the main menu

"ØØ3"

Main Menu {HELP}

There are 1Ø options in the main menu :-

input blood tests	- to save your blood test results
input urine tests	- to save your urine test results
input other information	- to save information such as hypos
change data	- to change the information stored
view data	- displays the information recorded
general information	- general information about diabetes
personal advice	- personal advice on insulin adjustment
screen control	- stops the introductory screens
set date	- sets the current date
clinic date	- sets the next clinic date

The following page explains each option in further detail.

"ØØ4"

Input blood tests {HELP}

When storing your blood test results you need to type in the time the test was taken and the result of the test e.g. Ø7.3Ø a.m. 8 If you type an incorrect time e.g. 3Ø.3Ø a.m. then you will get a message saying : invalid time-try again. You can then tape in the correct time. Similarly if you type in an incorrect blood test you will get an error message and a chance to enter it in again. Once you have typed in the time and result you may wish to enter further results by pressing RETURN . When you have finished press ESC. A message will appear asking you to press RETURN to continue. If you think you have typed the incorrect information press DEL to start again otherwise press RETURN and you will get back to the main menu.

"ØØ5"

Input Urine Tests {HELP}

When storing urine test results you just need to type in the result at the appropriate time. If the test is unavailable, forgotten or not taken then press Return at that time. If you took tests at a different time then you may put it in extra notes. If you type in an invalid test result you will get an error message and then you may type it in again. If you typed in the wrong result or a result at the wrong time then press DEL to start again.

"ØØ6"

Input Other Information {HELP}

All the information apart from blood and urine test results is stored here:

```
Carbohydrate - your daily carbohydrate allowance
Insulin      - your daily insulin intake
Hypos        - any occurence of hypoglycaemia
Exercise     - any exercise e.g. walking,tennis etc
Health       - any illness eg flu,sickness
Emotion      - anxiety,excitement etc
Holiday      - holidays
Extra Notes  - any matters related to diabetes
```

"ØØ7"

Input Insulin {HELP}

Your daily insulin intake should be stored here. There is no need to enter it every day. Only on those days that is changes. the new insulin levels should be entered. If you make an invalid insulin entry an error message will appear and you can type it in again. If you realise that you have typed in some incorrect information then you may press DEL to start again. Once you have completed input then a message will appear asking you to press RETURN to continue. You will then arrive back at the input other information menu

"ØØ8"

Input Hypoglycaemia {HELP}

When you have an attack of hypoglycaemia it is important that you record the time it happened. This option allows you to type the time of a hypo and if you have more than one then press return at the end of entering time. When you have finished press ESC but if you realise that you have typed an incorret time then press DEL to start again. If you type an invalid time then an error message will appear and you can type it in again. After ESC press Return and you will arrive back at Input Other Information Menu

"ØØ9"

Input Carbohydrate {HELP}

Your daily carbohydrate allowance should be input here. There is no need to enter it every day only these days it increases or decreases. The CHO for each meal should be entered. If you make an invalid entry an error message will appear and you can type it in again. If you realise that you have typed in some incorrect information then you may press DEL to start again. Once you have completed input then a message will appear asking you to press RETURN to continue. You will then arrive back at the Input Other Information Menu.

"Ø1Ø"

Input Health {HELP}

If you are ill then you need to record the information so that the doctor knows when you attend the clinic. Remember that if you feel poorly you may contact the health visitor or doctor. Input health presents a list of possible illnesses. Proceed down the list typing Y or N depending on whether you have the particular symptoms. If you press a key other than Y or N the system will just wait until you press the correct key. When you have finished, check that the information you typed in is correct. If not press DEL to start again otherwise RETURN to get back to Input Other Information Menu.

"Ø11"

Input Exercise {HELP}

If you participate in some exercise then it is useful to record it. You need to record the type of exercise and the time it started and finished. If you press an incorrect type of exercise then you will get an error message saying: invalid type -try again. You can then enter it again. Similarly if you type an incorrect time, an error message will appear before allowing you to enter it again. If you realise that you have entered incorrect information then press DEL to start again. Once you have completed the information then press RETURN to arrive back at the Input Other Information Menu.

"Ø12"

Input Holiday {HELP}

This option asks you if you are on holiday. You may press Y or N. If you press an incorrect key the system waits until you press Y or N. If you press N instead of Y or vice versa then press DEL to start again. If you are on holiday and cannot type the information in then record it in your diary and take it to your next clinic along with your disks. You should also put a note in Extra Notes with the dates of your holiday. Once the information is entered then press RETURN to arrive back at the Input Information Menu

"Ø13"

Stress {HELP}

If you are unduly anxious or upset it may affect your diabetes. To re cord this information, a list of possible emotions are presented. Proceed down the list typing Y or N for each emotion. If you press an incorrect key then the system will wait until you press Yor N. When you have finished check the information you typed in is correct. If not press DEL to start again otherwise press RETURN to get back to the Input Information Menu

"Ø14"

Input Extra Notes {HELP}

Sometimes you will need to record further information. Such as 'not well' but no actual symptoms or on holiday for 2 weeks. The information recorded here is all the little notes you may write in a diary. You may write any thing you like - if you make an error use backspace or DEL to start again. Once you have completed your extra note, press ESC and RETURN to get back to Input Other Information.

"Ø15"

Change Information Menu {HELP}

This option allows you to change any information you recorded other than today's information. Today's information may be changed via input data because it has not been stored permanently. However for change information you will need to know what to change and the corresponding date. You may wish to use view data in order to check the information you want to change first. The next pages of help describe each Change Information option in detail

"Ø16"

Change Information Menu {HELP}

Change blood test results - allows you to change the blood test results you have recorded

Change urine test results - allows you to change the urine test results you have recorded

Quit - takes you back to the main menu

The following pages describe each of the change options

"Ø17"

Change blood test results {HELP}

If for any reaon you wish to amend the blood test results recorded previously you may use this option. The first thing you need to know is the actual date you need to amend. When the date has been typed in the system will look for the blood test results recorded on that date. The results are then displayed and you may amend them. If the system cannot find the record for that day then a message will appear telling you so and you can type in another date.

"Ø18"

Change Urine Test Results {HELP}

If for any reaon you wish to amend the urine test results recorded previously you may use this option. The first thing you need to know is the actual date you need to amend. When the date has been typed in the system will look for the blood test results recorded on that date. The results are then displayed and you may amend them. If the system cannot find the record for that day then a message will appear telling you so and you can type in another date.

"Ø19"

View Data {HELP}

The information that you have recorded may be displayed on the screen using this option. The ammount and type of information that can be recorded is quite large so the information is presented on four different screens. The first screen displays the blood and urine test results. The second screen displays carbohydrate ,hypoglycaemia and insulin details. The third screen displays exercise, health, stress and holiday details. The fourth and final screen displays the extra notes that may have been recorded. The following page of help describe each part of the View Data option.

"Ø2Ø"

(View Data contd.) Blood and Urine Test Results {HELP}

The blood and urine test results appear together. The date is positioned to the left.

To view the next date's information - press the down arrow.
To view more information on the same date - press the right arrow.
To escape out of the option - press ESC.

Page forward for further information.

"Ø21"
(View Data contd.) Carbohydrate Insulin Hypos {HELP}

The carbohydrate, insulin and hypoglycaemia details appear together. The date is positioned to the left.
To view the next date's information - press the down arrow.
To view more information on the same date - press the right arrow.
To escape out of the option - press ESC.
Page forward for further information.
"Ø22"
(View Data contd.) Health Stress Exercise Holiday {HELP}

The health, stress, exercise, holiday detail appear together. The date is positioned to the left.
To view the next date's information - press the down arrow.
To view more information on the same date - press the right arrow.
To escape out of the option - press ESC.
Page forward for further information.
"Ø23"
Extra Notes {HELP}

The extra notes that you record are displayed on their own screen. The date is positioned too the left.
To view the next date's information - press the down arrow.
To escape out of the option - press ESC.
"Ø24"
General Information {HELP}

This option gives you general information on your condition (diabetes). The information is presented in a similar way to a book. The General Information menu lists the main topics within the option and you may select any topic. The page of information is displayed on the screen and you may page backwards or forwards when you are ready to do so.
To page forward - press the right pointing arrow.
To page backward - press the left pointing arrow.
To return to the menu - press ESC.
"Ø25"
Personal Advice {HELP}

This option aims to help you to manage your condition and get the maximum number of blood/urine test results as low as possible. This will help you to remain healthy. There are three sections to this option and they are all explained in detail in the appropriate sections of help. This section is useful when you have a diabetic problem such as persistent high test results or hypoglycaemia. In addition, summaries of the results of your blood/urine test are available including the number of hypos since the last clinic.
Page forward for further details.

"Ø26"

Personal Advice Menu {HELP}

Activity Chart	- illustrates how to adjust your insulin dose.
Test Result Summaries	- shows the totals of your blood/urine test results.
Problem Advice	- advises you when you have a particular problem e.g. persistent high test results.
Advice Request	- advises on recent blood/urine tests and hypos

Page forward for further details.

"Ø27"

Action Chart {HELP}

The actvity chart gives very brief guidelines for adjusting your insulin dose if you decide to alter it due to persistent high test results or hypoglycaemia. When you have a diabetic problem you need to identify the time when it occurs most and ensure that you are not skipping meals/snacks or eating 'extras'.In addition check your exercise if any before deciding that insulin is the cause. When you conclude that inulin does need to be adjusted you can use the chart to help you decide which insulin to adjust.
Page forward for further details.

"Ø28"

Action Chart (contd.) {HELP}

The left hand side of the chart lists the hours of the day and you need to find the hour closest to the time of your problem. Having done that you need to read accross to the right of the screen finding the column headed with your problem type (i.e. highs / hypos). The correct column will display the appropriate advice for your problem (i.e. increase/decrease insulin dose).
Page forward for further details.

"Ø29"

Action Chart (contd.) {HELP}

The first page of the activity chart displays the morning only simply because the screen is not large enough to diplay the whole day. The left and side of the chart lists the hours of the day and you need to find the hour closest to the time of your problem. Having done that you need to read accross to the right of the screen finding the column headed with your problem type (i.e.highs/hypos). The correct column will display the appropriate advice for your problem (i.e. increase/decrease insulin dose).
Page forward for further details.

"Ø3Ø"

Action Chart (contd.) {HELP}

The second page of the activity chart displays the afternoon only. The left hand side of the chart lists the hours of the day and you need to find the hour closest to the time of your problem. Having done that you need to read accross to the right of the screen finding the column headed with your problem type (i.e.highs/hypos). The correct column will display the appropriate advice for your problem (i.e. increase/decrease insulin dose).
Page forward for further details.

"Ø31"

Test Summaries {HELP}

The Test Summary section summarises all the blood test results, urine test results and occurrences of hypoglycaemia. The totals are presented along with the percentages. The last page compares your percentage results with the target by displaying them together.
The are four screens of information in this section :

- Blood Test Result Summaries
- Urine Test Result Summaries
- Hypoglycaemia Summaries
- Test Result Targets

In order to page through the information in the section Return is pressed.
Page forward for further details.

"Ø32"

Blood Test Result Summaries {HELP}

The blood test result summary summarises the blood test result totals and percentages. The totals and percentages are displayed in three categories :

< 4mmols	(below 4 mmols)	- below 'normal' blood sugar
> 4 mmols and < 9 mmols	(between 4 and 9 mmols)	- 'normal' blood sugar
> 9 mmols	(more than 9 mmols)	- above 'normal' blood sugar

Page forward for further details.

"Ø33"

Urine Test Result Summaries {HELP}

The urine test result summary summarises the urine test result totals and percentages.
The totals and percentages are displayed in three categories :

0%	- 'normal' blood sugar
1%	- up to 1% above 'normal' blood sugar
2%	- 2% above 'normal' blood sugar

Page forward for further details.

"Ø34"

Hypoglycaemia Summaries {HELP}

The hypoglycaemia summary show the date and time of the hypos. The hypo dates and times may need more than one screen to display then so RETURN is used to page throu the information. At the end of all the dates and times the number of hypo is displayed as a total.

Page forward for further details.

"Ø35"

Test Result Targets {HELP}

If the doctor at the diabetic clinic advises you to keep your blood and/or urine test results, say, 5Ø% being of 'normal' blood sugar levels then this can be entered at the clinic by the doctor. This section then compares your percentage results with the target by displaying them together. The test result targets is the last part of the section before returning to the main menu.

"Ø36"

Problem Advice {HELP}

This section helps you to decide what sort of problem you have, why it is happening and what should be done to prevent it happening. By 'problem' we mean 'diabetic problem', that is high blood and/or urine test results or hypoglycaemia. This may be due to illness, exercise, diet or insulin and sometimes it may be difficult to tell why it is happening. By answering a series of questions the system may be able to help you find the cause and in addition offer you some advice.

YOU DO NOT HAVE TO TAKE THE ADVICE.

Page forward for further information.

"Ø37"

Problem Advice (continued) {HELP}

Sometimes the problem wil be due to the quantity of insulin you are taking and it may need to be adjusted. If the system concludes that this may be the cause it indicate which insulin to adjust and by how much (2 units). The system will then ask you if you are going to take the advice. If you have a further problem soon afterwards it may be related to the first problem and again the system will give you some advice. If you take the advice you may also want to see the previous advice(the system will ask you at that stage). If you rely 'yes' then it will be displayed on the screen.

"Ø38"

Screen Control {HELP}

At the start of some of the options an introductory screen is displayed. There are three in all and some users may find them tedious after a while. This section allows you to stop any of them appearing. In addition, if you want them to be displayed again this section allows you to do just that. All you need do is answer 'y'es or 'n'o along side the appropriate screens.

"Ø39"

Set Date {HELP}

When the system is first used you may want to set the date and provided the batteries are o.k. the date will be maintained from then on. If you make a mistake on input you will get a message saying that it is incorrect before you get a chance to type it in again.

"Ø4Ø"

Set Clinic Date {HELP}

This section lets you type in the date of your next clinic. The date is then displayed on the screen along side the main menu as a reminder for you. If you make a mistake when typing the date in you will get an error message and a chance to type it in again.

"Ø41"

Advice Request {HELP}

This section advises you on your recent blood and urine tests. For example if the results are high persistently then you should think about whether you insulin should be altered. The tests are monitored and a message is displayed telling you if there is a problem or if there is no problem. Similarly your hypos are monitored and if they are persistent a message is displayed. If there is a problem with either test results or hypos the message tells you to go to the Problem Advice section.

"Ø42"

{HELP}

END OF HELP

Do not page forward - back or ESC only

APPENDIX VIII

GENERAL INFORMATION TEXT

"ØØØ"

You cannot page back any further.

Page forward to read general information.

"ØØ1"

GENERAL INFORMATION ON DIABETES

"ØØ2"

1. Introduction.

The aim of this computer system is to help you to manage your diabetes. 'Good management' means that your blood/urine tests should be as close to normal blood/urine glucose levels as possible. In order for you to do this you need to understand your condition and what to do to avoid high blood/urine test results. This section briefly tells you about your condition and how to manage it.More information is provided in the books and information given by your clinic and the British Diabetic Association.

Always rememeber that if you are in doubt about your condition you can talk to your doctor or health visitor.

"ØØ3"

2. What is diabetes.

Diabetes means that the body is unable to produce enough insulin. Insulin is required to convert the food you eat into energy. If there is inufficient insulin to do this then the food - in the form of glucose - in the blood ,spills into the urine. This makes the body very dry(dehydrated) and the diabetic feels very thirsty. Treatment is in the form of insulin, and a well balanced diet. Blood and/or urine tests are taken in order to check the balance between insulin, diet and energy used in exercise is correct.

"ØØ4"

3. Insulin

Children who become diabetic always require one or more injections of insulin per day. There are three types of insulin, quick-acting, medium-acting and long-acting. Medium-acting insulins are usually need to be mixed with quick-acting insulin in the syringe and given once or twice a day. Long-acting insulins are usually given once a day with short acting insulin added if necessary. Intermediate insulin is a ready mixed insulin given twice or four times per day. Sometimes diabetics give quick acting insulin before each meal and a long-acting before bed. Twice daily injections are given 15-3Ø mins before breakfast before the evening meal.

"ØØ5"
4. Adjusting insulin

Sometimes a change in the dose of insulin may be required.

The dose may be decreased because :
a. of increased exercise.
b. in the months following diagnosis you may produce a little insulin for a while.

The dose may be increased because :
a. of illness.
b. more insulin is required gradually as you grow up.

"ØØ6"
4. Adjusting insulin. - continued

If you often have hypos or high test results then you will need to adjust your dose. The general method is:

persistent high tests at a particular time	-	increase dose before that time next day
persistent hypos at a particular time	-	decrease dose before that time next day

Before deciding whether you should adjust your insulin dose you should ask yourself some questions.(on next page)

"ØØ7"
4.1 Problem - persistent high test at a particular time

The questions you should ask are:

1. Are you eating anything extra before this time?
2. Have you stopped exercising before this time?

If the answer is 'no' to both questions then you might try increasing your insulin dose. If you have stopped exercising then you may increase your insulin dose. The increase should be no more than 2 units to start and you must decide which insulin to increase. This is detailed in Personal advice in Advice chart. The chart is specific to your own insulin regime.

"ØØ8"
4.2 Problem - persistent hypos at a particular time
The questions you should ask are:
1. Have you decreased your carbohydrate allowance or missed your meal/snack?
2. Have you started exercising regularly before this time?
If the answer is 'no' to both questions then you might try decreasing your insulin dose.The decrease should be no more than 2 units to start with and you need to decide which insulin to decrease. This is detailed in Personal advice in Advice chart and is specific to your insulin regime. If you have started exercising then try extra carbohydrate(1Øg) just before starting. If the answer is 'yes' to the first question then you need to increase your carbohydrate allowance and ensure that you do not miss any meals/snacks.

"ØØ9"
5. Blood and urine tests

In order to check your 'sugar control' - that is how near to 'normal' your blood sugar levels are, you need to measure your blood glucose or urine glucose levels. Urine tests tell you what your blood glucose levels have been over the past few hours whereas blood tests tell you what your current blood glucose levels are. The results are best recorded so that you can see over a period of time how you are getting on and you should remember to take the diary to your clinic appointment so that you can talk about how your sugar control is getting on. When recording your results using this system you may take your disks to the clinic or a printer listing. The doctor will tell you what sort of test results you should be aiming for.

"Ø1Ø"
6. Hypoglycaemia (Hypo)

If your blood glucose level falls below 2.5 mmol/l you will become hypoglycaemic. The symptoms of a hypo can be different for each child but you should try and learn to recognise your own symptoms so that you can stop it quickly. As soon as you feel hypo you should eat 2-4 glucose tablets immediately. If you cannot eat because you are drowsy then a sweet drink may be taken. Once you have recovered, a snack (such as 2 biscuits and a cup of milk) should be taken to maintain your blood sugar levels until the next meal. If your meal is due immediately then there is no need to take a snack. Remember to note your hypos in your diary or 'Extra Notes'. If you have a severe attack mention it to your doctor so that it may be avoided in future.
"Ø11"
7. Hyperglycaemia and ketacidosis

If your blood glucose rises above 1Ø mmol/l your urine will show glucose and may indicate that you need more insulin.
Contact your doctor if:
1. urine test results are 2% or more for 3 days
2. urine test results are 5% and ketones are present for more than 2 tests in one day.
3. urine test results are 5% and ketones are present and you feel sick, vomit, become drowsy or breath deeply. N.B.you should be seen by a doctor or taken to hospital at once.

Remember to note any occurrence of ketones in 'Extra Notes'.
"Ø12"
8. Illness

Illnesses or temperature may upset your blood sugar control. The stress on the body usually makes the sugar go up and insulin will need to be increased. Illnesses with vomiting will still need insulin but also small sipps of sugar water.

NOTE - NEVER STOP INSULIN DURING ILLNESS
- IF WORRIED CONTACT YOUR DOCTOR

Try to do more tests at this time if possible. If you suffer a loss of appetite try to eat or drink most of your carbohydrate allowance in small regular portions. The clinic will advise you on what foods you should eat in an emergency when you are ill
Always remember - do not delay in asking for help

"Ø13"
9. Diet

Diabetics need a well balanced healthy diet which has a regular carbohydrate intake. Every diabetic has a personal daily carbohydrate allowance that is appropriate to their lifestyle. You will have your carbohydrate allowance calculated for you at the clinic, where the dietician will be available to help you. In addition, the dietician will recommend some books for you to read about the diabetic diet.

"Ø14"
10. Exercise

Regular exercise such as swimming keep you fit and allows your insulin to work more efficiently.
If you exercise regularly e.g.at school, you may need to alter your insulin or diet for those days. Extra carbohydrate may be eaten either at the meal before exercise or can be eaten as a snack just before participating. Some diabetics require extra carbohydrate several hours after exercise or sometimes the following day. You need to watch your blood/urine tests at the time and after exercise to decide what adjustments are appropriate for you. Sudden bursts of exercise such as squash will require fast releasing glucose at the time (eg mini mars bar, Dextrosols)

NOTE - ALWAYS CARRY FAST ACTING GLUCOSE

"Ø15""
11. Conclusion

Keep in good health by watching your 'sugar control'.
This is done by :
(i) always having your insulin.
(ii) following a healthy well balanced diet of regular carbohydrate.
(iii) checking regular blood/urine test results.
(iv) plenty of exercise to keep fit.

This system aims to help you, as a diabetic, record your day and assist you in making adjustments with your insulin dose.
The system will not replace the care and advice from the clinic doctor or health visitor but it may help how to control diabetes a bit better.
"Ø16"

END OF GENERAL INFORMATION

You cannot page forward any further

Page back to check any information

Additional page of text for female diabetic users :
(inserted after blood and urine tests)

"ØØØ"
5. Blood and Urine Tests - continued

Menstruation.

Menstruation may affect your diabetes. You may find it difficult to maintain low test results at this time.

You can record your menstrual period in "Extra Notes" so that your doctor has a record. Your doctor or health visitor will advise you if you need to increase your insulin at this time.

APPENDIX IX

EXAMPLE USER SESSION WITH DIABETIC SYSTEM

```
DIABETIC  MANAGEMENT  SYSTEM                date  17/5/1989
```

```
Hello, this is your Diabetic Management System.
It aims to help you manage your diabetes and learn about your condition.
You can keep all the information that you usually keep in your diary in
this system. Always remember that if you are worried for example, about
your blood tests it is best to talk to your doctor or health visitor.

    Some of the keys you will need to use are:

    F1   - top left hand corner              ↑   - right hand side
    ESC  - left hand corner                  ↓   - right hand side
                   RETURN  - bottom right hand side
                        press return to continue

                            F1 - help
```

```
DIABETIC  MANAGEMENT  SYSTEM                date  17/5/1989
```

```
 input blood tests                  Main Menu
 input urine tests                  ---------
 input other data
 change data
 view data               Your next clinic visit is on 1/9/1989
 general advice
 personal advice
 remove intros
 set date                Use ↑ ↓ and RETURN to make a selection
 clinic date
 quit

                             F1 - help
```

```
DIABETIC  MANAGEMENT  SYSTEM                date  17/5/1989
```

```
                        Input Blood Tests
                        -----------------
    Type the time of test and the corresponding blood test result.
    e.g. 05.30 p.m. result - 9  Press DEL to delete the page.
    Press RETURN to input more test results. Press ESC to terminate.

      __.__ _.m. result - __           __.__ _.m. result - __
      __.__ _.m. result - __           __.__ _.m. result - __
      __.__ _.m. result - __           __.__ _.m. result - __

                             F1 - help
```

```
DIABETIC  MANAGEMENT  SYSTEM            date  17/5/1989
```

```
                    Input Blood Tests
                    -----------------
  Type the time of test and the corresponding blood test result.
  e.g. 05.30 p.m. result - 9  Press DEL to delete the page.
  Press RETURN to input more test results. Press ESC to terminate.

     07.30 a.m. result - 9_        __.__ _.m. result - __
     __.__ _.m. result - __        __.__ _.m. result - __
     __.__ _.m. result - __        __.__ _.m. result - __

                 press return to continue

                       F1 - help
```

```
DIABETIC  MANAGEMENT  SYSTEM            date  17/5/1989
```

```
 input blood tests                Main Menu
 input urine tests                ---------
 input other data
 change data
 view data               Your next clinic visit is on 1/9/1989
 general advice
 personal advice
 remove intros
 set date                Use ↑ ↓ and RETURN to make a selection
 clinic date
 quit

                          F1 - help
```

```
DIABETIC  MANAGEMENT  SYSTEM            date  17/5/1989
```

```
 action chart                   Personal Advice
 test results                   ---------------
 problem advice
 view history
 advice request
 main menu

                      Use ↑ ↓  and RETURN to make a selection

                          F1 - help
```

DIABETIC MANAGEMENT SYSTEM date 17/5/1989

Personal Advice

The advice given to you in this section is for you only.
It is based on your blood and/or urine tests and lifestyle.
The advice given should not be used by another diabetic.

The advice is given with a corresponding reason why the advice
has been given to you.Read both the advice and the reason.
If you are in any doubt it is always best to contact your
doctor or health visitor.Further information about this section
is given in help.

press return to continue

F1 - help

DIABETIC MANAGEMENT SYSTEM date 17/5/1989

Personal Advice

Have you had any personal advice from this system in the last few days?

[Y]es or [N]o - [N]

F1 - help

DIABETIC MANAGEMENT SYSTEM date 17/5/1989

Personal Advice

Is the problem hypoglycaemia?

Please answer [Y]es or [N]o - [Y]

F1 - help

DIABETIC MANAGEMENT SYSTEM date 17/5/1989

Personal Advice

Are the hypos persistent?

Please answer [y]es or [No] - [Y]

F1 - help

DIABETIC MANAGEMENT SYSTEM date 17/5/1989

Personal Advice

Do the hypos occur at particular times?

Please answer [Y]es or [N]o - [Y]

F1 - help

DIABETIC MANAGEMENT SYSTEM date 17/5/1989

Personal Advice

Do you perform any exercise before the hypos occur?

Please answer [Y]es or [N]o - [N]

F1 - help

DIABETIC MANAGEMENT SYSTEM date 17/5/1989

Personal Advice

Have you missed a meal or snack before the hypos?

Please answer [Y]es or [N]o - [N]

F1 - help

DIABETIC MANAGEMENT SYSTEM date 17/5/1989

Personal Advice

Have you decreased your carbohydrate intake recently?

Please answer [Y]es or [N]o - [N]

F1 - help

DIABETIC MANAGEMENT SYSTEM date 17/5/1989

Personal Advice

Advice : Your insulin dose should be adjusted.

Reason : The hypos you are experiencing are persistent and they occur at particular times. It is unlikely that they are due to exercise or too little carbohydrate and therefore it is likely that your insulin dose is too high.

press return to continue

F1 - help

DIABETIC MANAGEMENT SYSTEM date 17/5/1989

Personal Advice

At what time does it occur? e.g [03.45 a.m.]
Time - [. .m.]

F1 - help

DIABETIC MANAGEMENT SYSTEM date 17/5/1989

Personal Advice

At what time does it occur? e.g [03.45 a.m.]
Time - [11.00 a.m.]

press return to continue

F1 - help

DIABETIC MANAGEMENT SYSTEM date 17/5/1989

Personal Advice

Advice : Decrease your pre breakfast quick acting insulin by 2 units.

Reason : Your hypos occur at the time when the quick acting insulin is most active.

Are you going to take this advice? [Y]es or [N]o [Y]

F1 - help

DIABETIC MANAGEMENT SYSTEM date 17/5/1989

action chart
test results
problem advice
view history
advice request
main menu

Personal Advice

Use ↑ ↓ and RETURN to make a selection

F1 - help

DIABETIC MANAGEMENT SYSTEM date 17/5/1989

input blood tests
input urine tests
input other data
change data
view data
general advice
personal advice
remove intros
set date
clinic date
quit

Main Menu

Your next clinic visit is on 1/9/1989

Use ↑ ↓ and RETURN to make a selection

F1 - help

APPENDIX X

PROPOSAL FOR INITIAL EVALUATION

Proposal for Evaluation of a Micro Based Advisor for the Management of Juvenile Diabetes Mellitus

The work will involve use of the system in the diabetics home and data gathered from approximately seven clinic visits. The clinics are held at monthly intervals but some will be unsuitable for this work. Some of the tasks will run concurrently at the same clinic.

The evaluation phase includes four tasks :

Evaluation of Data Capture and Interface Facilities

1. Home Based Evaluation of the Data Capture and Interface Facilities

The system should be installed in selected patients homes for a period of one month and used in parallel with the diabetic diary. The diabetic diaries and data collected should be compared. In addition, a log file holding the number of times each option was accessed should be examined.

The time required to complete this task will be :

1 clinic visit to meet the 6 participants
2 months (3 participants per month) to collect the data

2. Evaluation at Diabetic Clinic

Demonstrations at the diabetic clinic will be carried out and detailed questionnaires completed by the participants. A short demonstration at the diabetic clinics will involve approximately 20 participants.

The time required to complete this task will be :

4 clinic visits to demonstrate the system to 20 participants

Evaluation of the Advice Section of the System

Ethical Considerations

The problems of medical ethics mean that at the current time it is unacceptable to allow patients to use the system prospectively to treat their diabetic condition. The clinicians feel that to allow the system to be used unchecked in the diabetic's home would be analagous to the introduction of a new drug without first testing the drug for efficacy and side effects. Thus the evaluation of the advice section will take place in the controlled situation of the diabetic clinic.

3. Patient Based Evaluation

Selected patients will participate in controlled experiments involving presenting real and fictitious problems to the patients and noting the actions they will take to solve the problem. In addition, the problems should be entered into the system by the patients and the advice generated by the system examined.
The 10 participants will be presented with 6 problems that will be based on their personal insulin regime.

The time required to complete this task will be :

3 clinic visits to complete experiments with 10 participants.

4. Clinician's Evaluation

Copies of a number of diabetic diaries will be obtained and examined. The problems, i.e. hypos or high tests, and any action taken will be noted. The clinician may then be presented with the problems and asked to explain the necessary treatment. In addition the problems will be presented to the system. Both the advice from the clinician and the system will be compared.

The time required to complete this task will be :

Examination of log books to select problems - 4 weeks
Discussion of problems with the clinician
(approximately 30 minutes per patient)

Judith Jones 5.10.89
Leicester Polytechnic

APPENDIX XI

HOME BASED EVALUATION OF DATA CAPTURE AND INTERFACE FACILITIES : QUESTIONNAIRE AND RESULTS

DIABETIC MANAGEMENT SYSTEM QUESTIONNAIRE

To be completed by the families participating in the Diabetic Management System User Input Trials.

PARENTS

Occupation : ____________	Occupation : ____________
Computer Experience : None ☐ At home ☐ At work ☐ Other ☐	Computer Experience : None ☐ At home ☐ At work ☐ Other ☐

DIABETIC

Age ____
Age at diagnosis ____
Sex ____

Insulin Details(i.e. brand name(s), time of injection(s), dose)

Computer Experience :
- None ☐
- At home ☐
- At school ☐
- Other ☐

Who normally writes information in the Diabetic Record Book ?
- Parent(s) ☐
- Diabetic ☐
- Both ☐

When is the information written in the Diabetic Record Book ?
- At the end of the day ☐
- Throughout the day ☐
- Other - please specify ☐

Who entered the information into the Diabetic Management System ?
- Parent(s) ☐
- Diabetic ☐
- Both ☐

When was the information entered ?
- At the end of the day ☐
- Throughout the day ☐
- Other - please specify ☐

Please indicate on the numbered scale the extent to which you agree or disagree with the following statements.

ENTERING BLOOD TEST RESULTS

	Very much disagree 1	2	3	4	Very much agree 5
1. The information and instructions were easy to understand.	1	2	3	4	5
2. I would have preferred more information and instructions.	1	2	3	4	5
3. It was easy to enter blood tests.	1	2	3	4	5
4. This part of the system would be useful in the long term.	1	2	3	4	5
5. I would prefer to record blood tests in the Diabetic Record Book.	1	2	3	4	5
6. I found it time consuming to record blood tests using this system.	1	2	3	4	5
7. I would record blood tests using a system like this if it would definitely improve my (or my child's) blood sugar control.	1	2	3	4	5

Please add any comments, criticisms and suggestions you have regarding this part of the system.

INPUT OTHER DATA

	Very Much Disagree 1	2	3	4	Very Much Agree 5
1. It was easy to record my carbohydrate intake.	1	2	3	4	5
2. I would have preferred more instructions on how to enter carbohydrate information.	1	2	3	4	5
3. It was easy to record information about my insulin injections.	1	2	3	4	5
4. I would have preferred more instructions on how to enter insulin information.	1	2	3	4	5
5. It was easy to record hypos.	1	2	3	4	5
6. I would have preferred more instructions on how to enter hypos.	1	2	3	4	5
7. It was easy to record exercise.	1	2	3	4	5
8. I would have preferred more instructions on how to enter exercise.	1	2	3	4	5
9. It was easy to record illness.	1	2	3	4	5
10. I would have preferred more instructions on how to enter illness.	1	2	3	4	5
11. It was easy to record stress.	1	2	3	4	5
12. I would have preferred more instructions on how to enter stress.	1	2	3	4	5
13. It was easy to record holidays.	1	2	3	4	5
14. I would have preferred more instructions on how to record holidays.	1	2	3	4	5
15. It was easy to record extra notes.	1	2	3	4	5
16. I would have preferred more instructions on how to enter extra notes.	1	2	3	4	5

Please add any comments, criticisms and suggestions regarding this part (Input Other Data) of the system.

IN GENERAL

	Very much disagree				Very much agree
1. I found it time consuming to record any other data.	1	2	3	4	5
2. I found it easier to record any other data in 'Extra Notes'.	1	2	3	4	5
3. I would not mind recording any other data for a short time(days).	1	2	3	4	5
4. I would only record any other data if it would definitely improve my (or my child's) blood sugar control.	1	2	3	4	5
5. I would record insulin, carbohydrate and hypos regularly if I had a system like this.	1	2	3	4	5
6. The system would be more useful if it could provide general advice and information about diabetes.	1	2	3	4	5
7. If the system could offer advice (e.g. adjust insulin level) based on the recorded data it would be more useful.	1	2	3	4	5
8. If the system could offer advice I would prefer to ask the doctor or health visitor for advice.	1	2	3	4	5

Did you have any problems with the system ?

What were the main problems ?

Please add any comments, criticisms and suggestions you have regarding the overall system.

.

Thank you for participating in the Diabetic Management System user input trials and completing this questionnaire

Judith Jones(1990)
Leicester Polytechnic

HOME BASED EVALUATION - VOLUNTEER QUESTIONNAIRE REPLIES

PARENT'S DETAILS

Parents Occupations

	Mother	Computer Experience	Father	Computer Experience
1.	Occupational Therapist	work	Biochemist	home
2.	Student	educ.	Deceased	
3.	Local Government Clerk	work	Systems Manager	work, home
4.	Company Director	work	Company Director	work
5.	Nursery Nurse	work	Builder	none
6.	Post Office Clerk	none	Assistant Computer Shift Controller	work

DIABETIC'S DETAILS

	Sex	Diabetic's age	Term	Computer Experience
1.	female	10 years	1 year	home
2.	female	8 years	7 years	none
3.	male	11 years	1 year	home, school
4.	male	16 years	12 years	home, school, work
5.	female	13 years	9 years	school
6.	female	14 years	1 year	school

INSULIN REGIME

Brand	Time	Units
1. Human Actraphane 30/70	7.00 am 6.00 pm	12 6
2. Mixtard u100	7.30 am 6.00 pm	15 5
3. Actraphane (Penmix 30/70)	7.45 am 6.00 pm	7 6
4. Human Actrapide , Human Protophane	Before Breakfast Before Lunch Before Dinner Before Bed	
5. Insulatard Pork, Velosulin Pork	7.15 am 5.00 pm	6/28 6/28
6. Not Stated		

RESPONSIBILITY FOR UPDATING RECORD BOOKS AND SYSTEM

Who enters information in the Record Book	When is info entered in record book
1. Diabetic	Through day
2. Parents	End of day
3. Parents	Through day
4. Diabetic	Through day
5. Diabetic	Through day
6. Diabetic	Weekly or Through day
Who entered DMS onformation	**When was the information entered**
1. Parents	End of Day
2. Parents	End of Day
3. Parents	End of Week
4. Diabetic	End of day
5. Diabetic	Through day
6. Parents	Every 3/4 days

ENTERING BLOOD TESTS

	Disagree	Neither Agree or Disagree	Agree
The information and instructions were easy to understand	3 6	4	1 2 5
I would have preferred more information an instructions	2 5	4 6	1 3
It was easy to enter blood tests.	3 4 6	1 2 5	
This part of the system would be useful in the long term.		1 3 6	2 4 5
I would prefer to record blood tests in the record book	2 5	1 4	3 6
I found it time consuming to record blood tests using this system.	2 5	1	4 3 6
I would record blood tests using a system like this if it would definitely improve my (or my child's) blood sugar control.	1		2 3 4 5 6

Respondents Comments.

2. It would have been easier to enter blood tests if it recorded them.
4. Would like to exit program at any point.

ENTERING BLOOD TESTS

	Disagree	Neither Agree or Disagree	Agree
The information and instructions were easy to understand	3 6	4	1 2 5
I would have preferred more information an instructions	2 5	4 6	1 3
It was easy to enter blood tests.	3 4 6	1 2 5	
This part of the system would be useful in the long term.		1 3 6	2 4 5
I would prefer to record blood tests in the record book	2 5	1 4	3 6
I found it time consuming to record blood tests using this system.	2 5	1	4 3 6
I would record blood tests using a system like this if it would definitely improve my (or my child's) blood sugar control.	1		2 3 4 5 6

Respondents Comments.

2. It would have been easier to enter blood tests if it recorded them.
4. Would like to exit program at any point.

INPUT OTHER DATA

	Disagree	Neither Agree or Disagree	Agree
It was easy to record my carbohydrate intake.		2	4 5
I would have preferred more instructions on how to enter carbohydrate.	2 4 5		
It was easy to record information about my injections.			2 4 5
I would have preferred more instructions on how to enter insulin information.	2 4 5		
It was easy to record hypos.			2 1 4 5
I would have preferred more instructions on how to enter hypos.	2 4 5		
It was easy to record exercise.	2		4 5
I would have preferred more on how to enter exercise.	4 5	1	2
It was easy to record illness.			2 4 5
I would have preferred more instructions on how to enter illness.	2 4 5		
It was easy to record stress.		2	4 5
I would have preferred more instructions on how to enter stress.	2 4 5		
I would have preferred more instructions on how to record holidays.	5	1	4
It was easy to record extra notes.		2	1 4 5
I would have preferred more instructions on how to enter extra notes.	1 4 5	2	

Respondents Comments

1. For what we used, the system was satisfactory.
3. Not used.
6. Not used.

IN GENERAL

	Disagree	Neither Agree or Disagree	Agree
I found it time consuming to record 'any other data'.	5	2 4	
I found it easier to record 'Any Other Data' in 'Extra Notes'.		2	1 4 5
I would not mind recording 'Any Other Data' for a short time (days).		2 6	1 4 5
I would only record 'any other data' if it would definitely improve my (or my child's) blood sugar control.	1 4	2 5 6	3
I would record insulin, carbohydrate and hypos regularly if I had a system like this.	3 4 6		1 2 5
The system would be more useful if it could provide general advice and information about diabetes.			1 2 3 4 5 6
If the system could offer advice (e.g. adjust insulin level) based on the recorded data it would be more useful.			1 2 3 4 5 6
If the system could offer advice I would prefer to ask the Doctor or Health Visitor for advice.	4	3 5 6	1 2

Did you have any problems with the system ?

1. Initially yes. But once explained again it was O.K.

2. It did not record the data at all.

4. Keyboard problems. Would like to exit program at any point.

5. No

6. Yes

What were the main problems?

1. The system is set up to enter glucose levels only using BM test strips. We use Exacted strips and found that we could not enter the exact figures in the computer.

2. It did not record the data.

3. Too slow. PC too big.

4. Date entering. No exit.

5. Never had any.

6. Not easy for a person without PC experience to enter data.

Please add any comments, criticisms and suggestions you have regarding the overall system.

1. The overall system is quite satisfactory. It is easy to operate and to get into the programmes i.e. it is self explanatory. It would be nice if there was additional general information for young children who are diabetic, so they can learn more about it.

2. It would help if the system provided carbohydrate exchange i.e. how much carbohydrate each fruit or biscuits contains etc.

3. Basic idea is good if it could be extended to provide advice/guidance based on history.

4. The system is very useful to the just diagnosed diabetic. However after time the system would not be needed as the diabetics should make his own decision.

5. I found the system useful, and I enjoyed using this system.(diabetic aged 13)

   My daughter took over the computer research completely independently and she enjoyed using it. I wonder if the novelty would would have worn off given time.

6. Although an interesting exercise, I felt that using the system tended to "make a drama out of a crisis" for a reasonably controlled diabetic. However, I think it might be a considerable help to someone with constant problems with their sugar level.

APPENDIX XII

EVALUATION AT DIABETIC CLINIC OF DATA CAPTURE AND ADVICE INTERFACE FACILITIES : QUESTIONNAIRE AND RESULTS

LEICESTER POLYTECHNIC : DIABETIC MANAGEMENT SYSTEM

DEMONSTRATION QUESTIONNAIRE (i)

PARENTS

Occupation : ______________	Occupation : ______________
Computer experience :	Computer experience :
None ☐	None ☐
At home ☐	At home ☐
At work ☐	At work ☐
Other ☐	Other ☐

DIABETIC

Age ____
Age at diagnosis ____
Sex ____

Computer experience :
- None ☐
- At home ☐
- At school ☐
- Other ☐

If you have a home computer please specify the type.

What would you do if the following problem occurred :

Hypos occurring mid morning

What questions would you ask yourself or what checks would you make if you decided to adjust your insulin.

What diabetic problem did you see the Diabetic Management System qive advice on ?

What questions did the system ask before giving advice ? Please write down as many as you can remember.

What would you do if the following problem occurred :

Hypos occurring in the early hours of the morning

What questions would you ask yourself or what checks would you make if you decided to adjust your insulin.

Please indicate on the numbered scale the extent to which you agree or disagree with the following statements.

ENTERING BLOOD TEST RESULTS

	Very Much Disagree				Very Much Agree
1. The information and instructions were easy to understand.	1	2	3	4	5
2. I would have preferred more information and instructions.	1	2	3	4	5
3. It was easy to enter blood tests.	1	2	3	4	5
4. This part of the Diabetic Management System would be useful at home.	1	2	3	4	5
5. I would prefer to record blood tests in the Diabetic Record Book.	1	2	3	4	5

Please add any comments, criticisms and suggestions you have regarding this part of the system.

ADVICE SECTION OF THE SYSTEM

	Very Much Disagree 1	2	3	4	Very Much Agree 5
1. The information and instructions were easy to understand.	1	2	3	4	5
2. I would have preferred more information and instructions.	1	2	3	4	5
3. The questions were easy to understand and answer.	1	2	3	4	5
4. The advice was clear and easy to understand.	1	2	3	4	5
5. This part of the system would be useful at home.	1	2	3	4	5
6. The computer could provide advice on problems that I would have difficulty solving on my own.	1	2	3	4	5
7. The problems that the computer could help me with are straightforward.	1	2	3	4	5
8. The computer could help me solve some problems.	1	2	3	4	5

Please add any comments, criticisms and suggestions regarding the advice section of the system.

OVERALL

	Very Much Disagree 1	2	3	4	Very Much Agree 5
1. Overall, I would like to have a computer system like this.	1	2	3	4	5
2. I would only want a system like this if it would definitely improve my (or my child's) blood sugar control.	1	2	3	4	5
3. I would like a system like this to help me learn more about diabetes.	1	2	3	4	5
4. If I had a computer like this I would be unlikely to use it.	1	2	3	4	5
5. I would find a computer like this time consuming.	1	2	3	4	5
6. I think that a computer like this would be helpful occasionally.	1	2	3	4	5

Please add any comments, criticisms and suggestions you have regarding the overall computer system.

Thank you very much for participating in the demonstration and completing this questionnaire

Judith Jones (1990)
Leicester Polytechnic

LEICESTER POLYTECHNIC : DIABETIC MANAGEMENT SYSTEM

DEMONSTRATION QUESTIONNAIRE (ii)

PARENTS

Occupation : ______________ Occupation : ______________

Computer experience :
- None ☐
- At home ☐
- At work ☐
- Other ☐

Computer experience :
- None ☐
- At home ☐
- At work ☐
- Other ☐

DIABETIC

Age ____
Age at diagnosis ____
Sex ____

Computer experience :
- None ☐
- At home ☐
- At work ☐
- Other ☐

If you have a home computer please specify the type.

What would you do if the following problem occurred :

Hypos occurring in the early hours of the morning

What questions would you ask yourself or what checks would you make if you decided to adjust your insulin.

What diabetic problem did you see the Diabetic Management System give advice on ?

What questions did the system ask before giving advice ? Please write down as many as you can remember.

What would you do if the following problem occurred :

Hypos occurring mid morning

What questions would you ask yourself or what checks would you make if you decided to adjust your insulin.

* * * * * *

This questionnaire continues exactly as the previous questionnaire.

* * * * * *

CLINIC DEMONSTRATION REPORT

Personal Details

	Parents occupations		Computer Experience				Age at	
	Father	Mother	Male	Female	Child	Age	Diag	Sex
1.	B.T. Engineer	Caterer	h w	h w	h s	11	8	m
2.	------	--------	n		n	10	6	m
3.	------	Housewife	h	w	h s	12	7	f
4.	------	--------	h w	h w	h s	13	13	m
5.	Pharmacist	Nurse	o	h w	h s	10	9	f
6.	Director	Director	w	w	s w	16	4	m
7.	------	Housewife	h	h	h s	12	11	m
8.	Builder	Shop Assistant	n	n	s	7	5	m
9.	------	Designer	-	n	n	7	2	m
10.	Biochemist	Occupational Therapist	h	h	h s	9	9	f
11.	Builder	Nursery Nurse	n	w	s	13	4	f
12.	Asst. Computer Shift Controller	Post Office Clerk	w	n	h s	14	13	f
13.	Solicitor	Student	n	n	s	15	5	m
14.	Deceased	Student		w	h s	8	<1	f
15.	Sub-Contracts Controller	Building Society Manager	w	h w	h s	11	10	f

Computer Experience h - home w - work
s - school o - other n - none

DIABETIC PROBLEM SOLVING

	Pre Demo Problem: Solution Right	Pre Demo Problem: Solution Wrong	Pre Demo Problem: Solution Unsure	Pre Demo Problem: Evidence of Checks	Post Demo Problem: Solution Right	Post Demo Problem: Solution Wrong	Post Demo Problem: Solution Unsure	Post Demo Problem: Evidence of Checks
1.	*			*	*			*
2.		*		*		*		
3.	*			*			*	
4.	*			*	*			*
5.			*	*	*			*
6.	*			*	*			*
7.	*			*	*			*
8.	*			*	*			*
9.	*			*	*			*
10.	*			*	*			*
11.	*			*	*			*
12.	*			*	*			*
13.		*		*	*			*
14.	*			*	*			*
15.	*			*	*			*

Questions on Demonstration

What problem did the system give advice on ?
Correct Answers From Participants : 1 2 3 4 5 6 7 8 9 10 11 12 13 15
Incorrect Answers From Participants : 14

What questions did the system ask before giving advice ?															
Participant Number :	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Number of Questions Remembered	4	3	0	3	3	4	3	0	4	4	2	0	3	0	2

TOTAL FREQUENCY OF RESPONDENTS REPLIES

ENTERING BLOOD TESTS

	Disagree	Neither Agree or Disagree	Agree
The information and instructions were easy to understand *	2	2	10
I would have preferred more information an instructions	9	6	0
It was easy to enter blood tests.	2	1	12
This part of the system would be useful at home.	3	3	9
I would prefer to record blood tests in the record book	4	4	7

* One participant did not respond to this statement.

ADVICE SECTION OF THE SYSTEM

	Disagree	Neither Agree or Disagree	Agree
The information and instructions were easy to understand.	1	4	10
I would have preferred more information and instructions	9	4	2
The questions were easy to understand and answer.	1	2	12
The advice was clear and easy to understand.	1	2	12
This part of the system would be useful at home.	4	3	8
The computer could provide advice on problems that I would have difficulty solving on my own.	7	4	4
The problems that the computer could help me with are straightforward.	0	3	12
The computer could help me solve some problems.	3	3	9

OVERALL

	Disagree	Neither Agree or Disagree	Agree
Overall, I would like a computer system like this.	3	5	7
I would only want a system like * this if it would definitely improve my (or my child's) blood sugar control.	2	4	8
I would like a system like this to help me learn more about diabetes.	3	3	9
If I had a computer like this I would be unlikely to use it.	9	3	3
I would find a computer like this time consuming.	9	1	5
I think that a computer like this would be helpful occasionally.	6	5	4

* One participant did not respond to this statement.

INDIVIDUAL RESPONDENTS REPLIES

ENTERING BLOOD TESTS

	Disagree	Neither Agree or Disagree	Agree
The information and instructions * were easy to understand.	9 12	5 15	1 3 4 6 7 8 10 11 13 14
I would have preferred more information an instructions.	2 4 5 7 9 10 11 13 15	1 3 6 8 12 14	
It was easy to enter blood tests.	9 12	5	1 2 3 4 6 7 8 10 11 13 14 15
This part of the system would be useful at home.	2 7 9	1 8 12	3 4 5 6 10 11 13 14 15
I would prefer to record blood tests in the record book	3 5 11 14	6 1 4 13	2 7 8 9 10 12 15

* Participant 2 did not respond to this statement.

ADVICE SECTION OF THE SYSTEM

	Disagree	Neither Agree or Disagree	Agree
The information and instructions were easy to understand.	9	2 5 12 15	1 3 4 6 7 8 10 11 13 14
I would have preferred more information and instructions	4 5 6 7 9 10 11 12 14	1 3 8 13	2 15
The questions were easy to understand and answer.	9	5 12	1 2 3 4 6 7 8 10 11 13 14 15
The advice was clear and easy to understand.	9	5 15	1 2 3 4 6 7 8 10 11 12 13 14
This part of the system would be useful at home.	2 7 9 13	1 12 15	3 4 5 6 8 10 11 14
The computer could provide advice on problems that I would have difficulty solving on my own.	1 2 6 7 9 12 13	5 8 11 14	3 4 10 15
The problems that the computer could help me with are straightforward.		5 8 9	1 2 3 4 6 7 10 11 12 13 14 15
The computer could help me solve some problems.	1 2 7	9 10 11	3 4 5 6 8 12 13 14 15

OVERALL

	Disagree	Neither Agree or Disagree	Agree
Overall, I would like a computer system like this.	2 7 12	1 5 8 9 13	3 4 6 10 11 14 15
I would only want a system like this if it would definitely improve my (or my child's) blood sugar control. *	10 11	5 6 9 15	1 2 3 4 8 12 13 14
I would like a system like this to help me learn more about diabetes.	1 7 11	2 9 6	3 4 5 8 10 12 13 14 15
If I had a computer like this I would be unlikely to use it.	3 4 5 6 8 10 12 11 14	1 13 15	2 9 7
I would find a computer like this time consuming.	1 3 4 5 8 9 10 11 15	14	2 6 7 12 13
I think that a computer like this would be helpful occasionally.	5 9 10 11 14 15	2 3 4 6 7	1 8 12 13

* Participant 7 did not respond to this statement.

COMMENTS

The following comments are the exact comments made by the respondents.

Participant 4

Comments on Entering Blood Tests

Chris liked the idea of the computer as he is very keen on computers anyway.
I think as a parent that entering blood tests on a computer is a good idea if you have the facility permanently set up in the patients room, if not it would be just as quick and convenient using the record book.

Comments on Advice Facility

On this section we found it useful, as it very quickly brought to mind most of the information needed to sort out the problem. I found it helpful as Chris has only recently been diagnosed and we are not fully geared up to what questions to ask ourselves straight away.

General Comment

The instructions seemed to be clear and ask the right questions to solve the problem.

Participant 6

Comments on Entering Blood Tests

Would like to exit the program at any point.

Comments on Advice Facility

After many years of diabetes it is not really a lot of help. However if system points out a problem it is useful

General Comments

The system is useful and helpful if I didn't have to fill in a book as well as it would be useful. I think the system would be useful for the just diagnosed.

Participant 7

Comments on Entering Blood Tests

To me this system did not give anymore information than a little commonsense would do.

Comments on Advice Facilities

Same as before. Computer did not tell me anything I wouldn't already know.

General Comments

It's just as easy to write down in a record book and anyway if I was very concerned I would contact my Doctor not refer to a computer.

Participant 8

Comments on Entering Blood Tests

It was quite easy but in a book one can see at a glance how the blood sugars are going. I'm sure it would be more interesting for Richard though to record on a computer and would encourage him to be responsible for himself a bit more.

Comments on advice Facility

I think I would need more time to be shown how to use the computer to comment properly. Again I understood at the time but now find it difficult to remember.

General Comments

In my case my son is taking only a small amount of insulin and still in what is known as the 'honeymoon period'. We are not therefore experiencing any drastic swings in the blood sugars and I find I can more or less sort him out myself. I think an expensive computer would therefore be a waste of money on us at the moment. I can however see that for others and maybe for us in the future it could be a good supportive help.

Participant 10

Comments on Entering Blood Tests

It is best to record in the Diabetic Management System and in the record book just in case if one is lost.

Participant 11

General Comments

It was Okay from what I saw.

APPENDIX XIII

PATIENT BASED EVALUATION OF ADVICE FACILITIES : QUESTIONNAIRE AND RESULTS

DIABETIC PROBLEM SOLVING QUESTIONNAIRE

PARENT(S)

Occupation : ______________ Occupation : ______________

DIABETIC

Age ____
Age at diagnosis ____
Sex ____

Insulin Details(i.e. brand name(s), time of injection(s), dose)

Do you adjust the insulin level between clinic visits ?

Who decides what adjustments should be made ?

Why might you decide to adjust the level of insulin ?

There are a number of diabetic problems presented on the next page. Please describe the action you would take if you had each of these problems.
For example, if you would adjust the insulin dose then write down which insulin you would adjust, at what time and by how much.
If you are unsure then you may put a question mark in the space.
If you would call the Health Visitor or Doctor then put HV (for health visitor) or D (for doctor).

DIABETIC PROBLEMS

A. Hypos occuring in the early hours of the morning.

B. High blood test results occuring in the morning.

C. A hypo occuring after a sports lesson at school.

D. Hypos occuring just before the mid morning snack is eaten.

E. High blood test results occuring in the evening.

F. High blood test results occurring when the diabetic has flu.

REPORT ON DIABETIC PROBLEM SOLVING QUESTIONNAIRE

Parents occupations Father	 Mother	Age	Age At Diagnosis	Sex
1.Systems Manager	Local Govt. clerk	11	10	m
2.Deceased	Student	8	11 mths	f
3.Company Director	Company Director	16	3.5 yrs	m
4.Fitter/wireman	Shop assistant	5	2	f
5 Warehouse Manager	Accounts clerk	14	12	f
6.Managing Director	Housewife	17	4	m
7.Travel Agent	Housewife	4	4	f
8.------------	--------------	11	9	f
9.Computer shift Controller	Post Office Assistant	13	13	f
10.Production Controller	Housewife	6	5	f
11.Painter & Decorator	Cashier	12	4	f
12.-------------	--------------	17	2	f
13.Biochemist	Occupational Therapist	10	9	f

INSULIN DETAILS

Brand	Time	Units
1. Novo Labs Human Actraphane (Penmix 30/70)	7.45 am 6.00 pm	7 6
2. Mixtard u100	B B B D	15 5
3. Human Actrapide , Human Protaphane	B B B L B D B Be	
4. Human Mixtard	7.30 am 5.30 pm	13 8
5. Human Actrapid	B B B L B D	6 - 10 6 - 10 6 - 10
Human Protophane	B B	20
6. U100 Velosulin	B B B L B D	20 20 20
U100 Insulatard	B Be	27
7. Human Protophane	8.30 am 6.30 pm	5 3
8. Human Mixtard	am pm	16 16
9. Human Actraphane	7.30 6.30	18 18
10. Human Actraphane	am pm	10 10
11. Actraphane	am pm	24 12
12. Human Actrapid	8.00 am 12.30 pm 6.00 pm	2 4 6
Human Monotard	B Be	25
13. Human Actraphane 30/70 100iu/ml	7.30 am 6.00 pm	12 6

Key
B B - Before Breakfast   B L - Before Lunch
B D - Before Dinner   B Be - Before Bed

The following pages contain the actual respondent replies.

Do you adjust the insulin level between clinic visits ?

1. No
2. Yes
3. Yes
4. Sometimes
5. Yes
6. Yes , if required to do so.
7. Not normally unless advised. Only once by ourselves.
8. Sometimes.
9. If necessary.
10. Yes.
11. Yes.
12. Not usually. I adjust my insulin levels according to my general blood tests.
13. Sometimes

Who decides what adjustments should be made ?

1. In consultation with hospital.
2. Mother.
3. Diabetic.
4. Parents or the doctor.
5. Mother.
6. Mother or Doctor.
7. Consultant or Local Health Visitor.
8. Mother.
9. Parents.
10. Mother.
11. Mother.
12. Diabetic.
13. Parents

Why might you decide to adjust the level of insulin.

1. Blood sugar readings too high.
2. Only if the sugar level is very high and due to illness.
3. Sugar level activities.
4. If high sugar readings in the morning we would increase evening insulin. If frequent hypos we would decrease it.
5. Either my blood sugar is too high or low. Doing a lot of sports, going swimming.
6. High/ low blood sugar level, continuous hypos.
7. The daytime amount appeared to be too low. Blood levels became erratic.
8. Hypo or high tests.
9. Have only adjusted downwards following several low blood tests.
10. Sugar levels.
11. Too many hypos. Too many high blood sugars.
12. ie gaining weight - so I reduce my insulin take in.
13. 2 units at a time

DIABETIC PROBLEMS

PROBLEM A. Hypos occurring in the early hours of the morning.

1. Ask doctor.
2. Just give some HYPOSTOP in her mouth.
3. Have less morning insulin.
   if before 7 a.m. less evening insulin.
4. I would decrease insulin by 1 unit. We would give HYPOSTOP if she is unable to take Lucozade or Dextrosol tablet.
5. I would go and get a bit of chocolate and something to eat.
6. Reduction of 'before bedtime' insulin. I would first reduce the Insulatard by 5 units and see what the blood sugars before breakfast were like.
7. ?
8. Decrease insulin in evening.
9. Give glucose/adjust evening insulin dose by two units.
10. ?
11. Adjust evening insulin (down) by two units.
12. I would reduce my insulin take in because I have got too much. I would look at how much insulin I had been taking and would reduce it accordingly.
13. If conscious, apply fast acting Dextrose gel on the inside of the mouth. If not inject glucagon.

PROBLEM B. High blood test results occurring in the morning.

1. Ask doctor.
2. Increase the evening injection by 2 units.
3. More insulin.
4. I would increase evening insulin by 1 unit.
5. I would put my 'before bed' injection units up by a couple of units, or give myself more insulin in the morning.
6. Assuming that these tests were conducted about one hour after breakfast, an increase in Velosulin insulin before breakfast would be given. A reduction in the amount of breakfast could be combined with this.
7. ?
8. Increase insulin in evening.
9. Adjust evening insulin dose by two units.
10. ?
11. Adjust evening dose by 2 units.
12. I would have to increase my insulin take in because I have not got enough in me to counteract my blood readings or food intake etc.
13. If occasional do not vary insulin levels. If it happens for a few days try to increase insulin level by 2 units, or if in doubt consult with health visitor or Doctor.

PROBLEM C. A hypo occurring after a sports lesson.

1. Take Dextrose
2. Give a bit extra portion before the sport starts and if severe then 2oz of lucozade followed by 2 lines of carbohydrate intake.
3. Eat something before activity.
4. School keeps a bottle of Hypostop for such emergency but normally an extra snack before sports or P.E. should be taken i.e. 2 digestive biscuits.
5. I would give myself some glucose tablets or get some sweets off my friends.
6. This is possibly due to not having enough 'extra snack' before the sports lesson. I would not have 15-20 grams of carbohydrate extra.
7. ?
8. Extra dextrosol and snack.
9. Give glucose/chocolate.
10. Give Hypostop and glucose.
11. Treat hypo then in future give additional food before activity.
12. I usually have food (biscuits) straight away as I find that this reacts quicker than eating sweets.
13. Try to bring her out of it by giving her sugar, glucose preferably in water.

PROBLEM D. Hypos occurring just before the mid-morning snack is eaten.

1. Take Dextrose.
2. If you think it is due to exercise then increase mid-morning snack by 2 lines and if it is constant then decrease morning insulin by 1 unit.
3. Less morning insulin.
4. If this happened frequently I would decrease morning insulin by 1 unit or give her a biscuit on the way to school to keep her going until her snack.
5. Take mid-morning snack and give myself some sugar.
6. Due to the timing of these hypos they are probably due to too much insulin before breakfast. I would reduce the insulin first by 5 units, further reduction would depend upon blood sugar tests.
7. ?
8. Have snack early.
9. Adjust the morning insulin dose by two units.
10. Reduce the insulin.
11. Adjust the morning dose of insulin by 2 units or eat more at breakfast time.
12. I usually have food (biscuits) straight away as I find that this reacts quicker than eating sweets.
13. Consult Doctor, or try reducing morning insulin amount.

PROBLEM E. High blood test results occurring in the evening.

1. Ask doctor.
2. Increase morning insulin by 2 units.
3. More insulin before tea/dinner.
4. I would increase evening dosage by 1 unit.
5. Give myself more insulin.
6. I would imagine this would be due to not enough insulin before the evening meal. Depending upon how high the test was I would perhaps increase the Velosulin by 5 units and then alter it according to further tests.
7. We find it difficult to ascertain why it has arisen, against the type of food eaten.
8. Increase insulin in morning.
9. Adjust morning insulin dose by 2 units.
10. ?
11. Reduce morning insulin by 2 units or eat larger afternoon snack.
12. Increase dosage.
13. Try to reduce insulin levels, after consulting with Health Visitor or Doctor.

PROBLEM F. High blood test results occurring when the diabetic also has flu.

1. Ask doctor.
2. Increase morning insulin accordingly.
3. More blood tests and insulin adjustment.
4. This is to be expected so I would increase insulin dose accordingly possibly 2 units a.m. and 1 unit p.m. until levels start to get back to normal then put them back to usual dosage.
5. Give myself a bit more insulin if sugar is 17+ but if below I would leave it.
6. This would require constant blood sugar testing and extra injections to bring down the high test. The amount of insulin would greatly depend upon how high the test results where but I would suggest doses of 10 units. If the test results were continuously high over a period of say 36 hours I would contemplate calling a doctor.
7. ?
8. ?
9. Call the health visitor.
10. Increase the insulin.
11. Increase the insulin temporarily.
12. Increase dosage in accordance with the medication received from my GP.
13. Flu symptoms, sometimes tend to increase blood sugar levels, so we would normally ignore the effect.

APPENDIX XIV

CLINICIAN BASED EVALUATION OF ADVICE FACILITIES : RESULTS

Results of Clinician Based Evaluation of Advice Facilities

Record Book 1 - 7 problems

Diabetic details : Insulin regime - 2 injections per day
Insulin - Actraphane

Problem 1

Problem Description
Three out of ten high blood test results in the evening taken over one week. The associated comment notes that the child has flu.

Action Noted in Book
Extra test taken. No adjustment in insulin. Comment on flu symptoms and treatment.
Clinicians Advice
Most of the tests are O.K. and as the child has flu (high tests are to be expected) a change in insulin is not necessary. Remind the family that more tests should be taken at this time.
Systems Advice
No specific advice other than a reminder to take more tests when the patient has flu. If further tests proved to be high the system would then issue a warning that a change in insulin was appropriate.

Problem 2

Problem Description
Three out of ten high blood test results in the evening taken over one week.

Action Noted in Book
Extra tests taken. 2 units extra of a.m. Actraphane .
Clinicians Advice
Most of the tests are O.K. More tests should be taken.
Systems Advice
No specific advice other than a reminder to take more tests. If further tests proved to be high the system would then issue a warning that a change in insulin was appropriate.

Problem 3

Problem Description
Four consecutive high blood test results in the evening taken over four days. The patient was changing to a different type of Actraphane.

Action Noted in Book
Extra tests taken. Extra Actraphane for both a.m and p.m. injections.
Clinicians Advice
More tests should be taken. Increase insulin levels.
Systems Advice
Increase insulin by 2 units in a.m. and p.m. Take more tests. If further tests proved to be high the system would then issue a warning that another increase in insulin was appropriate.

Problem 4

Problem Description
Four consecutive high blood test results in the evening taken over four days.

Action Noted in Book
Extra tests taken. A hypo was noted at the start of the highs. The patient was also on holiday and eating the wrong sort of food. Several changes made to a.m. quick acting before arriving at pre problem level.
Clinicians Advice
More tests should be taken. No change in insulin levels.
Systems Advice
Increase long acting insulin by 1 unit in a.m. Take more tests. If further tests proved to be high the system would then issue a warning that another increase in insulin was appropriate.

Problem 5

Problem Description
Three high blood test results in the evening taken over five days.

Action Noted in Book
No action taken.
Clinicians Advice
More tests should be taken. No change in insulin levels.
Systems Advice
No advice issued but a general comment prompting further blood tests

Problem 6

Problem Description
Four high blood test results in the evening taken over eight days.

Action Noted in Book
No action taken.
Clinicians Advice
More tests should be taken. No change in insulin levels.
Systems Advice
No advice issued but a general comment prompting further blood tests

Problem 7

Problem Description
Scattered high blood test results in the evening taken over eight days.

Action Noted in Book
No action taken.
Clinicians Advice
More tests should be taken. No change in insulin levels.
Systems Advice
No advice issued but a general comment prompting further blood tests

Clinician's General Comment on Record Book 1

The problem that persists through the record book is high tests in the evening. It is a common problem. It may be due to the patient arriving home from school and eating a snack or it may be due to not enough a.m. long acting insulin. This problem is difficult to sort out and must be done by trial and error.

Record Book 2 - 2 problems

Diabetic details : Insulin regime - 2 injections per day
Insulin - Humulin I

Problem 1

Problem Description
Four consecutive high blood test results in the evening.

Action Noted in Book
It was noted that extra evening insulin had been given on each occasion.

Clinicians Advice
The extra evening insulin was incorrect. The appropriate action was to increase morning insulin. Remind the patient that more tests should be taken.

Systems Advice
An increase in a.m. insulin and a reminder to take more tests.

Problem 2

Problem Description
Four high out of seven blood tests in the evening.

Action Noted in Book
It was noted that extra evening insulin had been given on each occasion.

Clinicians Advice's
The extra evening insulin was incorrect. The appropriate action was to increase morning insulin. Remind the patient that more tests should be taken.

Systems Advice
An increase in a.m. insulin and a reminder to take more tests.

Record Book 3 - 6 problems

Diabetic details : Insulin regime - 2 injections per day
Insulin - Actrapid , Insulatard

Problem 1 and 2

Problem Description
Many high tests, many hypos.

Action Noted in Book
Many insulin changes. Extra CHO for hypos. Many tests taken. The patient was on holiday in Majorca.
Clinicians Advice
The patient should not adjust insulin this many times. The holiday may be affecting the problem.
Systems Advice
If a patient indicates frquent insulin changes a warning is given. In order to solve the problems here, the initial highs would be controlled by one insulin change and a wait for 3 days before further advice. The system, given all this information would advise the patient to contact the doctor.

Problems 3 to 6

Problem Description
Scattered high tests. Occasional hypos.

Action Noted in Book
Many insulin changes. Extra CHO for hypos. Many tests taken.
Clinician's Advice
The patient should not adjust insulin this many times.
System's Advice
If a patient indicates frquent insulin changes a warning is given. In order to solve the problems here, the initial highs would be advised with one insulin change and a wait for 3 days before further advice. The system, given all this information would advise the patient to contact the doctor. .

Clinician's General Comment on Record Book 3

This patient was not the clinician's patient. The record book was extremely unusual. Many tests were taken (at least 2 per day) and insulin levels were changed very often. This method of management was not advisable because there was no time to gauge the effect of one insulin change before another adjustment.

Record Book 4 - 1 problem

Diabetic details : Insulin regime - 2 injections per day
Insulin - Actraphane 30/70

Problem 1

Problem Description
Six high tests over eight days. Patient has 'flu.

Action Noted in Book
Increased a.m. long acting insulin.
Clinician's Advice
Increase a.m. long acting insulin. Check carbohydrate. More tests should be taken.
System's Advice
At the end of the eight days an increase in a.m. long acting would be recommended. More tests would be advised.

Record Book 5 - 4 problems

Newly diagnosed diabetic in remission
Diabetic details : Insulin regime - 2 injections per day
Insulin - Actrapid, Monotard

Problem 1

Problem Description
Three high tests over seven days.

Action Noted in Book
No action.
Clinician's Advice
No action.
Systems Advice
No action.

Problem 2

Problem Description
Four evening high tests over seven days.

Action Noted in Book
Increase a.m. Monotard insulin by 1 unit.
Clinician's Advice
Increase a.m. Monotard insulin by 1 unit.
System's Advice
Increase a.m. Monotard insulin by 1 unit. Remind the patient to take more tests.

Problem 3

Problem Description
Six evening high tests over eight days.

Action Noted in Book
Increase a.m. Monotard insulin by 1 unit.
Clinician's Advice
Increase a.m. Monotard insulin by 1 unit.
System's Advice
Increase a.m. Monotard insulin by 1 unit. Remind the patient to take more tests.

Problem 4

Problem Description
Four evening high tests over six days.

Action Noted in Book
Increase a.m. Monotard insulin by 1 unit.
Clinician's Advice
Increase a.m. Monotard insulin by 1 unit.
System's Advice
Increase a.m. Monotard insulin by 1 unit. Remind the patient to take more tests.

Record Book 6 - 3 problems

Newly diagnosed diabetic in remission
Diabetic Details : Insulin regime - 2 injections per day
Insulin - Actraphane

Problem 1

Problem Description
Four high tests over four days.

Action Noted in Book
Increase a.m. insulin
Clinician's Advice
Increase a.m. insulin.
System's Advice
Increase a.m. insulin. Remind the patient to take more tests

Problem 2

Problem Description
Five high evening tests over four days.

Action Noted in Book
Change insulin. No other action
Clinician's Advice
Change insulin so wait.
Systems Advice
No specific advice. Remind the patient to take more tests.

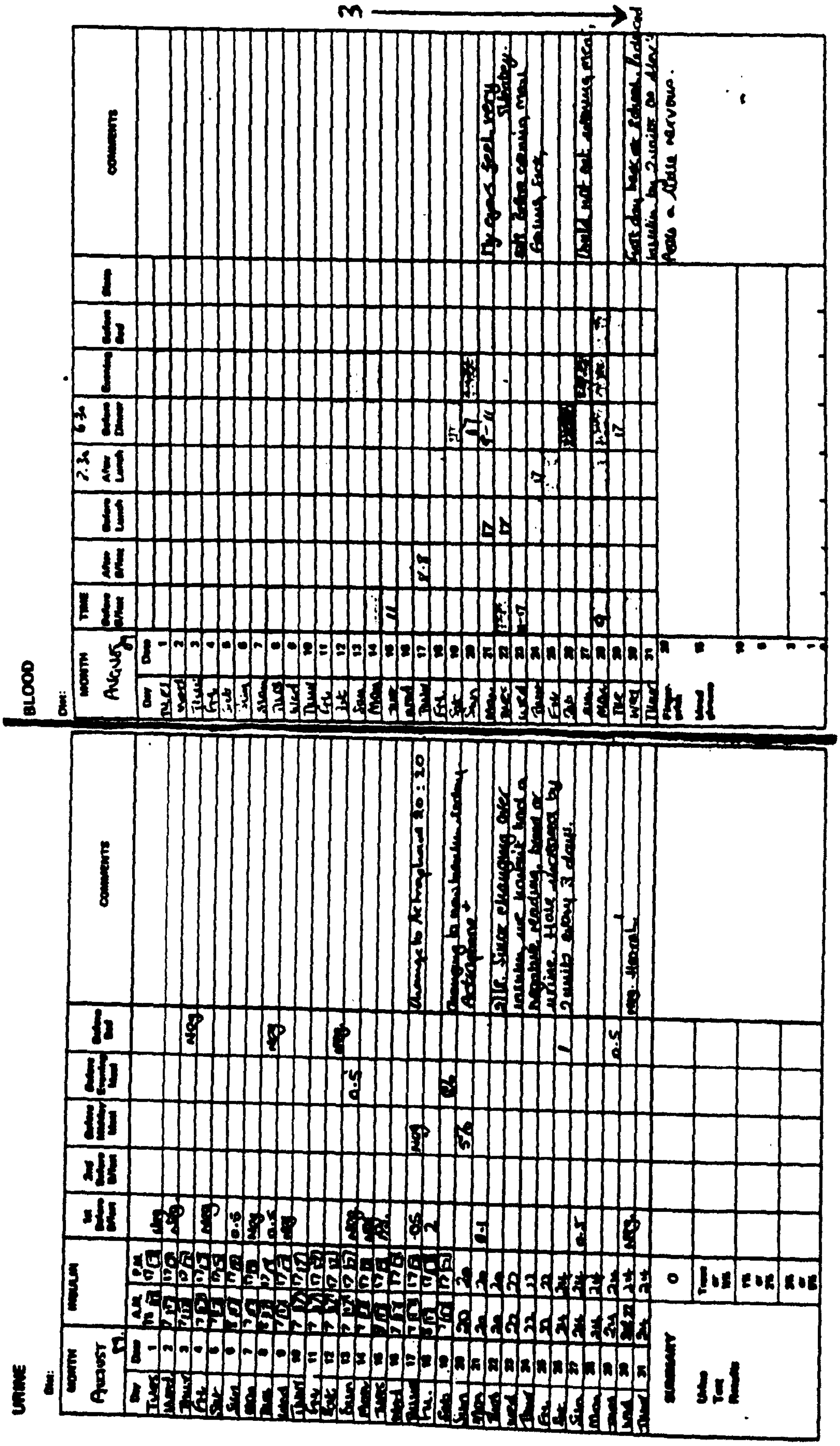
Problem 3

Problem Description
Three high evening tests over four days.

Action Noted in Book
Increase evening insulin by 1 unit.
Clinicians Advice
Increase evening insulin.
Systems Advice
No specific advice. Remind the patient to take more tests - if the following evening test was high then the system would advise an increase in insulin.

Sample Pages From The Diabetic Record Books

Record Book 1



URINE BLOOD.

Diet: 5 3 5 1 5 3 : 22

Day	Date	Insulin A.M. (Humulin I 25 & 10)	P.M.	1st Before B/fast	2nd Before B/fast	Before Midday Meal	Before Evening Meal	Before Bed	Comments
									[illegible] Really Good Month
WED	1								
THUR	2			9			13 2 at 5		
FRI	3						9		
SAT	4								
SUN	5						11		
MON	6			4.5					
TUES	7			3.0			6.5		
WED	8			3.0			11		
THUR	9								
FRI	10						9		
SAT	11			6.5			[illegible]		
SUN	12						11		
MON	13			2			11		
TUES	14			6.5			6.5		
WED	15			4					
THUR	16			2					
FRI	17			6.5			6.5		
SAT	18			11					
SUN	19						11 2 at 5		
MON	20			6.5					
TUE	21						6.5		
WED	22			9					
THUR	23						17 3 at 5.		
FRI	24						17 3 at 5		
SAT	25			6.5			13 2 at 5		
SUN	26						17 2 at 5		
MON	27			6.5					
TUE	28								
WED	29								
THUR	30			6.5			13		
FRI	31								

SUMMARY Urine Test Results						
0						
Trace or ½%						
1% or 2%						
3% or 5%						

URINE BLOOD

Diet:

Day	Date (Month: March)	Time: Before B/fast	After B/fast	Before Lunch	After Lunch	Before Dinner	Evening	Before Bed	Sleep	Comments
SAT	1	6.5								
SUN	2									
MON	3					6.5				
TUE	4	4.5								
WED	5	6.5								
THUR	6	6.5								
FRI	7									
SAT	8	6.5				13-4				
SUN	9	6.5				20	2 at 5			
MON	10									
TUE	11									
WED	12	6.5				17	2 at 5			
	13									
	14									
	15									
	16									
	17									
	18									
	19									
	20									
	21									
	22									
	23									
	24									
	25									
	26									
	27									
	28									
	29									
	30									
	31									

Finger-prick blood glucose

20

15

10

5

3

1

0

BLOOD

Dist:

MONTH: July

Day	Date	Before B/fast	After B/fast	Before Lunch	After Lunch	Before Dinner	Evening	Before Bed	Sleep	COMMENTS
		* = CKKE								
Sat	1	15.7				10.1	8.1		*18.0	Holiday to Majorca
Sun	2	16.0		20.2*		20.2		3.8		
Mon	3	12.9		12.4		5.9		5.7		
Tues	4	15.4		23.8		14.1		21.5*		
Wed	5	19.6*		6.8		20.1*	12.5*	10.7	18.6*	
Thurs	6	8.1		17.7*		23.6*		7.2	9.9	
Fri	7	13.9	23.2*			18.9*		18.2*		
Sat	8	12.5		14.9		12.5		7.3		
Sun	9	9.1		9.5		9.7		[illegible]		
Mon	10	14.8				7.7		16.2		
Tues	11	14.8		6.6		3.3		17.3*		Ill
Wed	12	16.2		6.1		19.2*		21.2*		" NO Lunch or Supper [illegible]
Thurs	13	14.6		20.6*		13.6		10.7		
Fri	14	7.3				5.3		27.6*		
Sat	15	17.8		10.2		16.2			13.2	HOME
Sun	16	11.1*		5.0		23.8*		20.1		
Mon	17	14.9				12.9				
Tues	18	16.7		15.2		14.3				
Wed	19	12.9		5.3		14.1				
Thurs	20	10.0				9.5		4.1		Hypo 11.45 PM
Fri	21	6.0				6.0	[illegible]	[illegible]		UP 5 times in night [illegible]
Sat	22	19.6*				12.8		—		
Sun	23	9.2				9.4		5.6		
Mon	24	14.8		3.0		5.9		5.5		Feeling hypo at 12.00 ([illegible])
Tues	25	15.8*		6.4	[illegible]	7.3				Feeling hypo at 12.00 ([illegible])
Wed	26	10.0				3.7				Hypo 2.30 am
Thurs	27	6.9				4.[illegible]	[illegible]	6.0		
Fri	28	9.9				11.[illegible]				
Sat	29	13.2				17.7*				
Sun	30	19.3				3.5				
Mon	31	11.2				5.6		[illegible]		

Finger-prick blood glucose: 20, 15, 10, 5, 3, 1

URINE

Dist:

MONTH: July

Day	Date	INSULIN A.M.	INSULIN P.M.	1st Before B/fast	2nd Before B/fast	Before Midday Meal	Before Evening Meal	Before Bed	COMMENTS
Sat	1	3+36	2+4						
Sun	2	3+37	2+4						
Mon	3	3+37	2+3						
Tues	4	[illegible]	2+3						
Wed	5	5+27	2+4						
Thurs	6	5+23	2+4						
Fri	7	7+23	3+5						
Sat	8	9+23	5+5						
Sun	9	10+23	6+4						
Mon	10	12+23	6+4						
Tues	11	2+23	5+5						
Wed	12	[illegible]	6+6						
Thurs	13	5+24	6+6						
Fri	14	16+23	5+5						
Sat	15	2+23	[illegible]						
Sun	16	4+23	5+6						
Mon	17	5+24	5+5						
Tues	18	18+24	6+6						
Wed	19	20+36	7+7						
Thurs	20	18+33	7+7						
Fri	21	16+32	7+7						
Sat	22	21+34	8+6						
Sun	23	21+34	8+10						
Mon	24	23+32	7+11						
Tues	25	25+34	8+12						
Wed	26	22+34	5+10						
Thurs	27	21+34	5+5						
Fri	28	15+34	6+5						
Sat	29	3+32	6+8						
Sun	30	5+32	5+7						
Mon	31	4+31	5+8						

SUMMARY

Urine Test Results: 0 / Trace / 1% or 2% / 3% or 5%

URINE

Diet:

Day	Date	Insulin A.M.	Insulin P.M.	1st Before B/fast	2nd Before B/fast	Before Midday Meal	Before Evening Meal	Before Bed	Comments	
		Actrapid Rapitard 30/70								
FRI.	1	14	14	0					R.LEG.	R.LEG
SAT	2	14	14	0					L.BUM	R.BUM
SUN	3	14	14	0					L.ARM	L.LEG.
MON	4	14	14	0					L.LEG	R.LEG
TUES	5	14	14	0					L.BUM	R.BUM
WED	6	14	14	0					L.LEG.	R.LEG.
THUR	7	14	14	0					L.BUM	R.BUM.
FRI	8	14	14.	0			5%	0.25	L.ARM.	L.BUM.
SAT	9	14	14				0		L.BUM.	R.BUM
SUN	10	14	14					TRACE	L.LEG	R.LEG.
MON	11	14	14	0					L.BUM	R.BUM.
TUES	12	14	14	1%					L.LEG.	R.LEG
WED	13	14.	14.	0				0	L.BUM.	R.BUM
THUR	14	14	14	0					L.LEG	R.LEG
FRI	15	14	14	0					L.BUM	R.BUM.
SAT	16	14	14	0					L.ARM	L.ARM
SUN	17	14	14	0		0			R.ARM	R.LEG
MON	18	14	14	0				5%	L.LEG	R.LEG
TUES	19	14	14	0					L.BUM	R.BUM
WED	20	14	14	0				0	L.LEG	L.TUM
THUR	21	14	14					3%	L.[illegible] BUM	R.[illegible] BUM
FRI	22	14	14	0			0		L.LEG	R.TUM
SAT	23	14.	14					2%	R.LEG.	L.LEG
SUN	24	14	16	0			0		L.BUM	[illegible]
MON	25	16	16	0			2%		R.BUM	L.BUM
TUES	26	16.	16.	0		0	4%		L.BUM	L.LEG.
WED	27	16	18					5%	L.LEG.	L.ARM.
THUR	28	16.	18	5%					L.LEG.	R.LEG
FRI.	29	18	18	0					L.ARM	L.BUM
SAT	30	18	18	0				0.	R.ARM	L.ARM.
SUN	31	18	18.	0			0		L.TUM	R.TUM

SUMMARY						
Urine Test Results	0					
	Trace or ½%					
	1% or 2%					
	3% or 5%					

BLOOD

Diet:

Day	Date	Before B/fast	After B/fast	Before Lunch	After Lunch	Before Dinner	Evening	Before Bed	Sleep	Comments
MONTH: DEC.		TIME								
FRI	1					9.				
SAT	2									
SUN	3									
MON	4									
TUES	5									
WED	6							8		
THUR	7							9		
FRI	8					17+				"GOD KNOWS WHY."
SAT	9			6.5						
SUN	10			9		2		9.		
MON	11							8.		SCHOOL MEALS WE THINK.
TUES	12					17		3		
WED	13					3				
THUR	14									
FRI	15					17				
SAT	16					11				ALL WITH FAM.
SUN	17	8								HE REALLY IS A MISERABLE
MON	18							17		PATIENT.
TUES	19							8		
WED	20					17				PARTY AT SCHOOL.
THUR	21							11		
FRI	22							17		
SAT	23									
SUN	24			4.5				3		
MON	25									
TUES	26									
WED	27	8				28.				
THUR	28									
FRI	29	4.5				3			2.	
SAT	30									
SUN	31			3						

Finger-prick blood glucose: 20, 15, 10, 5, 3, 1, 0

URINE

Disc:

MONTH: FEB		INSULIN: MONOTARD		1st Before B/fast	2nd Before B/fast	Before Midday Meal	Before Evening Meal	Before Bed	COMMENTS
Day	Date	A.M.	P.M.						
WED	1			3			0	0	very tired Thirsty
THU	2			.25		[illegible]		0.1	1 Tablet at [illegible] Wee in night
FRI	3			5	5	[illegible]		5	Thirsty 2 wees in night
SAT	4			5		0.1	0	0.5	w.n
SUN	5			2		0		5	Thirsty
MON	6		[illegible]	2				0.1	Tummy Ache
TUE	7	[illegible] 2		1			0	0.1	[illegible] 11 am (Sherry) [illegible]
WED	8	-	[illegible]	0.5		0		2	
THU	9	-		5		0.5		2	
FRI.	10	-		0.1		0		1	Phoned 11.00 am Dr Swift
SAT	11	[illegible] 4		5		0.5		2	Please get [illegible] Dr Swift
SUN	12	✓		2		0	0	-	
MON	13	✓		1			0	3	
TUE	14	✓		5				2	
WED	15	✓		2			0.25	5	
THU	16	✓		5				0.1	
FRI	17	✓		3			0		
SAT	18	✓		1		0	0	0.25	
SUN	19	✓		0			0	2	
MON	20	✓		1				0	
TUE	21	✓		0.5			0	2	
WED	22	✓		3				0.05	
THU	23	✓		2			0	1[illegible]	Ring Dr Swift 2 pm. Hosp. [illegible]
FRI	24			-	0		1	.2	
SAT	25	✓		3		1		1	
SUN	26	✓		2				5	
MON	27	✓		3			0	0	
TUE	28	✓		0				.5	
~~WED~~	29								
	30								
	31								

SUMMARY Urine Test Results						
0	2	1	5	11	4	
Trace or ¼%	4		4	1	7	
1% or 2%	10		1	1	6	
3% or 5%	11	1			9	

BLOOD

Disc:

MONTH: FEB.		TIME: Before B/fast	After B/fast	Before Lunch	After Lunch	Before Dinner	Evening	Before Bed	Sleep	COMMENTS
Day	Date									
WED	1		11							
	2									
FRI	3		11							
SAT	4	6.5								
SUN	5							28		
MON	6		8							
TUE	7		17							
WED	8				9					
THU	9							17		
FRI	10	6.5								
SAT	11			3.9			17			
SUN	12							5.7		
MON	13					10.8				
TUE	14							13.2		
WED	15					10.0				
THU	16		3.3							
FRI	17						4.8			
SAT	18			4.4						
SUN	19							15.8		
MON	20					3.4				
TUE	21						13.7			
WED	22		14.3					10.7		
THU	23									
FRI	24						[illegible]	[illegible]		
SAT	25									
SUN	26				6.9					
MON	27									
TUE	28							[illegible]		CK KE
~~WED~~	29						[illegible]			
	30									
	31									

Finger-prick blood glucose

20
15
10
5
3
1

22 | 23

Your doctor will advise you which tests you should perform.

Sugar levels to Low reduce to 6 units twice day

Date	Insulin AM	AM	PM	PM	Blood *				*		*		Urine Before breakfast	Before mid-day meal	Before evening meal	Before bed	Comments
June																	
22/6	7		7		5.1				5.4				Neg				(Dinner)
23/6	7		7		3.2								Neg				Hypo at school passed out cannot
24/6	7		6		5.7				2.3				Neg				remember anything about it.
25/6	6		6		7.4				13			3.8		Neg		Neg	feeling very tearful & weak.
26/6	6		6		6.9								Neg				
27/6	6		4		5.3	2.6								Neg			
28/6	4		4		4.9				9				Neg			Neg	Reduce Insulin to 4+4
29/6	4		4		6.2				10				Neg				(Home from School 5 days)
30/6	4		4		7.6												
July																	
1/7	4		4		5.4				4.6								
2/7	4		4		3.7				7.1				Neg				
3/7	4		4		20												
4/7	4		4		9				6.4				Neg				Travelled well no problems
5/7	4		4		6.5				6.5				Neg				Sick this morning first day on holiday
6/7	4		4		4.5				9					Neg		[illegible]	
7/7	4		4		4.5				9								
8/7	4		4		9				17						5		
9/7	4		5		9				9					[illegible]			
10/7	5		5		6.5				4.5							[illegible]	